[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

WK HO180S - 13 - P0243 4

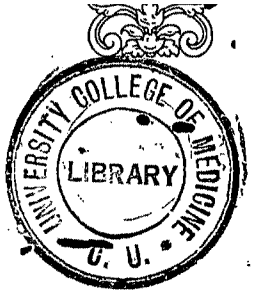
The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D

(15)

VOLUME 49

JANUARY TO JUNE, 1943



CHARLES C THOMAS : SPRINGFIELD, I
1943

COPYRIGHT, 1943
BY AMERICAN ROENTGEN RAY SOCIETY, INC.

WN 69

P, 2A, 395

CONTENTS OF VOLUME 49

ORIGINAL ARTICLES

The Rôle of the Gynecologist in the Field of Cancer: Janeway Lecture, 1942	*William P. Healy, M.D.*	1
The Dust Hazard in Tremolite Talc Mining, Including Roentgenological Findings in Talc Workers	*William Siegal* *Adelaide Ross Smith* *Leonard Greenburg*	11
Virus Pneumonia: Roentgenographic Characterization of Recent Virus Pneumonitis with Bronchopneumonia	*Asa E. Seeds, M.D.* *Morton L. Mazer, M.D.*	30
Duodenal Ulcer Syndrome Caused by Ankylostomiasis: Report of Twenty-five Cases with Gastric Acidity and Roentgenological Studies	*H.A. Yenikomshian, M.D., D.T.M.&H., M.R.C.P.* *William H. Shehadi, M.D.*	39
Development, Clinical Manifestations, and Treatment of Rheumatoid Arthritis of the Apophyseal Intervertebral Joints	*Albert Oppenheimer, M.D.*	49
Chondrodystrophia Calcificans Congenita	*Gerard Raap, M.D.*	77
The Prevention of Irradiation Sickness: Use of Vitamin B_1 in Roentgen Therapy	*William H. Whitmore, M.D.*	83
Classification of Epithelial Cancers Based upon Site of Origin	*E. A. Merritt, M.D.* *Ralph M. Caulk, M.D.*	99
The Effect of Roentgen Irradiation on Epiphyseal Growth. I. Experimental Studies upon the Albino Rat	*Joseph S. Barr, M.D.* *James R. Lingley, M.D.* *Edward A. Gall, M.D.*	104
A Simple Way to Hold a Filter in Place on Contact Therapy Tubes	*U. V. Portmann, M.D.*	128
Mediastinal Pleurisy in Infants	*Roger A. Harvey, M.D.*	145
Study of the "Widened" Mediastinum in Children and Pitfalls in Diagnosis	*A. V. Shapiro, M.D.* *Leo Bell, M.D.*	159
Oil Aspiration Pneumonia	*Morris Moel, M.D., B.S.* *Henry K. Taylor, M.D., F.A.C.P., F.A.C.R.*	177
Roentgenologic Considerations in the Diagnosis and Treatment of Diaphragmatic Hernia	*Stuart W. Harrington, M.D.*	185
Carcinoma of the Head of the Pancreas Demonstrating the New Signs in Roentgen Diagnosis: Case Report	*Paul S. Friedman, M.D.*	197
The Diagnosis of Posterior Protrusion of the Intervertebral Disc	*Thomas Horwitz, M.D.*	199
Intraspinal Thorotrast	*William A. Nosik, M.D.*	214
Pyogenic Osteomyelitis of the Thoracic Spine Presenting as Primary Pulmonary Disease	*Harry A. Solomon, M.D.* *Arnold L. Bachman, M.D.*	219
The Therapeutic Value of Roentgen Treatment in Chronic Asthma	*Wayne M. Hull, M.D.* *Ray M. Balyeat, M.D.* *L. K. Chont, M.D.*	227
Radium Therapy as an Aid in the Control of Chronic Otorrhea	*Ernest B. Emerson, Jr., M.D.* *Andrew H. Dowdy, M.D.*	234
Radon Treatment	*Stephen Klinghoffer, Ph.D.*	240
Effect of Roentgen Irradiation on Capillary Permeability and Inflammation in the Skin of the Rabbit	*R. H. Rigdon* *Howard Curl*	
Newer Aspects of Cancer Research. Caldwell Lecture, 1942	*C. P. Rhoads, M.D.*	280

Million Volt Roentgen Therapy for Intrathoracic Cancer: Palliative Effects in a Series of Sixty-three Cases	*William L. Watson, M.D., F.A.C.S.*; *Jerome Urban, M.D.*	299
Post-irradiation Stricture of Rectum and Sigmoid Following Treatment for Cervical Cancer	*Palmer E. Wigby, M.D., F.A.C.R.*	307
The Effect of Roentgen Rays upon the Growing Long Bones of Albino Rats. II. Histopathological Changes Involving Endochondral Growth Centers	*Charles L. Hinkel, M.D., Med. Sc.D.*	321
Contributions of Roentgenology to the Diagnosis of Chronic Constrictive Pericarditis	*Harold J. Stewart*; *John R. Carty*; *John R. Seal*	349
The Diagnosis of Congenital Heart Lesions in Children	*G. W. Grier, M.D.*	366
Leiomyosarcoma of the Stomach	*Clinton G. Lyons, M.D.*; *Martin Schneider, M.D.*	393
Melorheostosis; Report of a Bilateral Case	*J. W. J. Carpender, M.D.*; *D. R. Baker, M.D.*; *S. P. Perry, M.D.*; *Tom Outland, M.D.*	398
Hemophilic Arthritis; Roentgenographic Studies in Fifteen Adult Patients with Hemophilia	*Eugene J. McDonald, M.D.*; *Eugene L. Lozner, M.D.*	405
Roentgenography of the External Ear	*Arthur W. Fuchs, Major, S.C.*	420
Bleeding in Hiatus Hernia	*Otto D. Sahler, M.D.*; *Aubrey O. Hampton, M.D.*	433
Bleeding Associated with Extramucosal Tumors of the Stomach	*Otto D. Sahler, M.D.*; *Aubrey O. Hampton, M.D.*	442
Secondary Lymphosarcoma of the Stomach	*Franz Buschke, M.D.*; *Simeon T. Cantril, M.D.*; *E. L. Jenkinson, M.D.*	450
A Prenatal Diagnosis of Osteopetrosis	*W. H. Pfisterer, M.D.*; *K. K. Latteier, M.D.*; *Mary Martin, M.D.*	455
Ghon's Tubercle	*Robert G. Bloch, M.D.*	463
Ten Thousand Chest Examinations with the Stereoscopic Photoroentgen Unit	*Joseph Levitin, Lt. Col., M.C.*	469
The Roentgenologic Diagnosis of Dilatations of the Spinal Cord Veins	*Bernard S. Epstein, M.D.*; *Leo M. Davidoff, M.D.*	476
Experiences with Roentgen Irradiation following Operation on Brain Tumors	*Stuart N. Rowe, M.D., F.A.C.S.*; *Harold W. Jacox, M.D.*	480
Cancer of the Uterus	*Harry H. Bowing, M.D.*; *Robert E. Fricke, M.D.*	487
The Elimination of Irradiation Injuries in the Treatment of Cancer of the Cervix	*Charles L. Martin, E.E., M.D., F.A.C.R.*	49
An Instrument for Inserting Multiple Capsules of Radium within the Uterus in the Treatment of Corpus Cancer	*James F. Nolan, M.D.*; *A. N. Arneson, M.D.*	504
Cancer of the Cervix	*William P. Healy, M.D.*; *Gray H. Twombly, M.D.*	519
The Production and Characteristics of 3,000 Kilovolt Roentgen Rays	*J. G. Trump, D.Sc.*; *R. W. Cloud, M.A.*	531
Preliminary Clinical Observations on the Use of 3 Million Volt Roentgen Rays	*Richard Dresser, M.D.*	536
Duplication of Roentgenograms by the Light Reversal Process	*George C. Henny, M.D.*; *Gustavus C. Bird, Jr., M.D.*; *Herbert M. Stauffer, M.D.*	554
A Critical Analysis of the Roentgen Signs of Infantile Scurvy	*Ralph S. Bromer, M.D.*	575

Calcification of Renal Tumors	*George Austen, Jr., M.D.*	580
Roentgenologic Examination of the Pharynx	*Siegfried W. Westing, M.D.*	587
Post-traumatic Necrosis of Bone	*Raymond W. Lewis, M.D.*	593
Extraordinary Calcification in the Breast	*Benjamin W. Anthony, M.D.* *Herbert C. Pollack, M.D.*	600
Osteopoikilosis: A Case Report	*Roy H. Thompson, Lt. Col., M.C.* *Reuben Hoover, Major, M.C.* *Huston F. Fulton, M.D.*	603
The Roentgen Treatment of Cancer of the Esophagus	*D. W. Smithers, M.D., D.M.R.* *J. R. Clarkson, Ph.D.* *J. A. Strong, M.Sc.*	606
Roentgen Therapy of "Virus" Pneumonia	*Albert Oppenheimer, M.D.*	635
Radiation Hazards during Roentgenoscopy	*Thomas N. White, Ph.D.* *Dean B. Cowie, B.S.* *Alfred A. de Lorimier, M.D.*	639
Protective Features Provided with the United States Army Field Roentgenoscopic Equipment	*Alfred A. de Lorimier, M.D.* *Dean B. Cowie, B.S.* *Thomas N. White, Ph.D.*	653
Studies on the Indirect Effect of Roentgen Rays in Single and Parabiotic Mice	*W. A. Barnes, M.D.* *O. B. Furth, M.D.*	662
An Investigation into some Practical Aspects of Roentgen-Ray Stereoptics	*Edward Klein, D.D.S.* *Milton Klein, D.D.S.* *Harold Klein, D.D.S.* *Allen T. Newman, M.D.*	682
Roentgenologic Changes in the Small Intestine in the Presence of the Hookworm	*George R. Krause, Major, M.C.* *James A. Crilly, First Lt., M.C.*	719
Roentgenographic Obstetrical Pelvicephalometry in the Erect Position	*Robert P. Ball, M.D.* *Ross Golden, M.D.*	731
Analysis of Roentgen Pelvimetry by the Johnson Stereoroentgenometer in 379 Cases	*J. N. Ané, M.D.* *Leon J. Menville, M.D.*	742
Roentgenologic Localization of the Placenta without Contrast Media	*R. Manges Smith, M.D.*	750
Syphilitic Spondylitis	*Eugene Freedman, M.D.* *I. Meschan, M.D.*	756
Angiocardiography in Congenital Heart Disease. II. Intracardiac Shunts	*M. F. Steinberg, M.D.* *A. Grishman, M.D.* *M. L. Sussman, M.D.*	766
Miliary Calcification of the Lung	*Erving F. Geever, M.D.*	777
Layer Formation in Pyelography	*Alice Ettinger*	783
Variability in Onset of Ossification in Epiphyses and Short Bones of the Extremities	*Idell Pyle, M.S.* *L. W. Sontag, M.D.*	795
Radiation Treatment of Lymphangioma	*George W. Holmes, M.D.* *Lloyd E. Hawes, M.D.*	799
New Type of Radium Loading Protective Device	*Andrew H. Dowdy, M.D.* *Benjamin DuBilier, M.D.* *Dean B. Cowie*	803
Artificial Decrease of the Radiosensitivity of the Skin and Mucous Membranes in Roentgen Therapy	*Dr. Pierre Lehmann*	811
Cavernous Hemangioma of the Face in an Infant Treated with Radium	*A. W. Jacobs, M.D.*	816
Isodose Charts for Fields of Special Usefulness in the Treatment of Cancer of the Uterine Cervix	*Sidney M. Silverstone, M.A., M.B., B.Ch. (Cambridge)* *Carl B. Braestrup* *Bernard S. Wolf, M.D.*	819
An Inexpensive Gasette Changer for Angiocardiography	*Edward B. D. Neuhauser, M.D.* *Charles G. Jennings, M.D.*	829

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 JANUARY, 1943 NO. 1

CONTENTS

The Rôle of the Gynecologist in the Field of Cancer: Janeway Lecture, 1942 . . . . . WILLIAM P. HEALY, M.D. 1

The Dust Hazard in Tremolite Talc Mining, Including Roentgenological Findings in Talc Workers . . . . . WILLIAM SIEGAL, ADELAIDE ROSS SMITH AND LEONARD GREENBURG 11

Virus Pneumonia: Roentgenographic Characterization of Recent Virus Pneumonitis with Bronchopneumonia . . . . . ASA E. SEEDS, M.D., AND MORTON L. MAZER, M.D. 30

Duodenal Ulcer Syndrome Caused by Ankylostomiasis: Report of Twenty-five Cases with Gastric Acidity and Roentgenological Studies . . . . . H. A. YENIKOMSHIAN, M.D., D.T.M.&H., M.R.C.P., AND WILLIAM H. SHEHADI, M.D. 39

Development, Clinical Manifestations, and Treatment of Rheumatoid Arthritis of the Apophyseal Intervertebral Joints ALBERT OPPENHEIMER, M.D. 49

Chondrodystrophia Calcificans Congenita . . . GERARD RAAP, M.D. 77

The Prevention of Irradiation Sickness: Use of Vitamin B_1 in Roentgen Therapy . . . . . WILLIAM H. WHITMORE, M.D. 83

Classification of Epithelial Cancers Based upon Site of Origin . . . . . E. A. MERRITT, M.D., AND RALPH M. CAULK, M.D. 99

The Effect of Roentgen Irradiation on Epiphyseal Growth. I. Experimental Studies upon the Albino Rat . . . . JOSEPH S. BARR, M.D., . . . JAMES R. LINGLEY, M.D., AND EDWARD A. GALL, M.D. 104

Editorial

The Obturator Sign in the Early Roentgen Diagnosis of Septic Arthritis of the Hip 117

Society Proceedings, Correspondence and News Items 119

Book Reviews 125

Department of Technique

A Simple Way to Hold a Filter in Place on Contact Therapy Tubes . . . . . U. V. PORTMANN, M.D. 128

Abstracts of Roentgen and Radium Literature 129

GENERAL INFORMATION

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

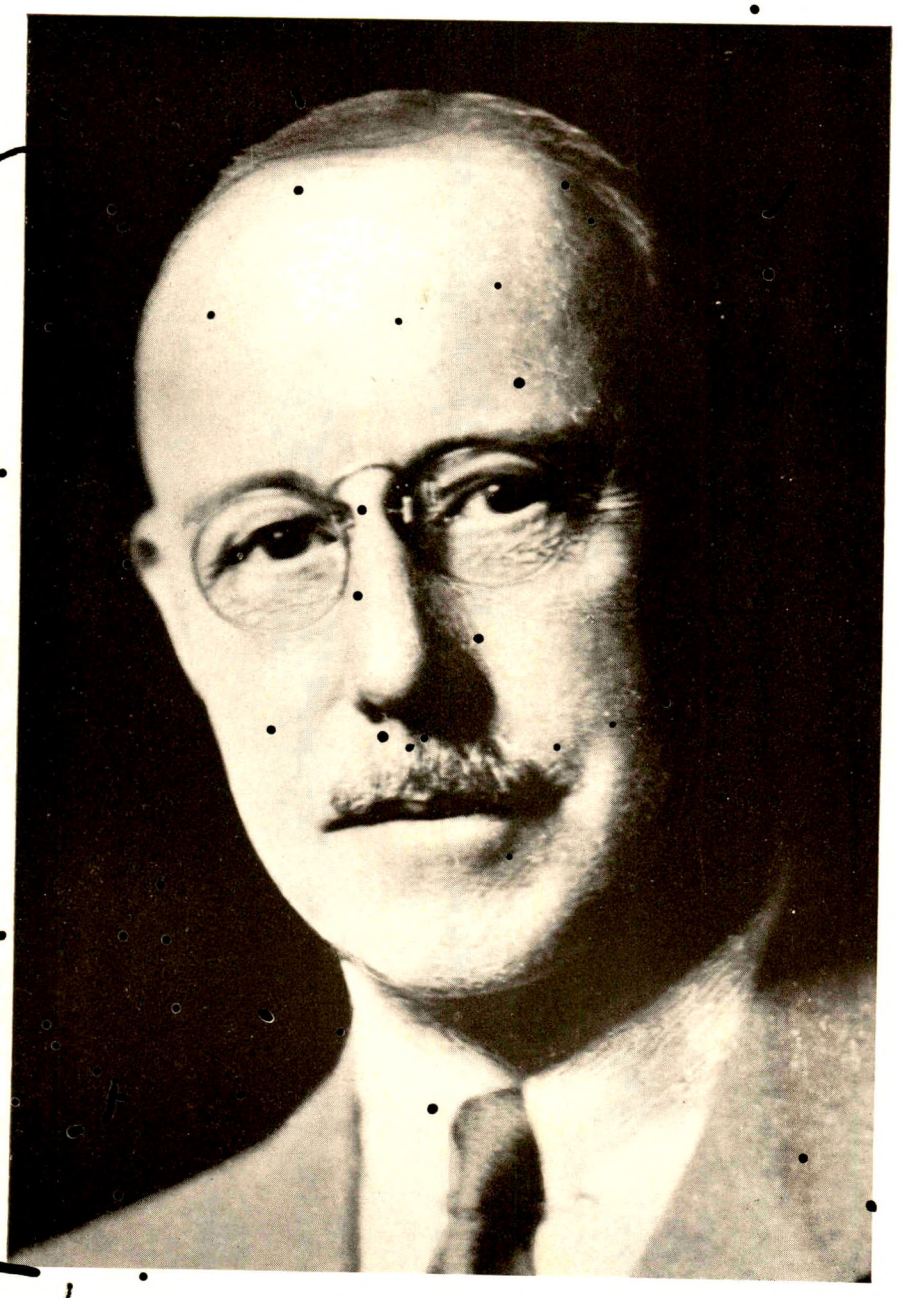
The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publishers.



William P. Healy
Janeway Lecturer, 1942

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 · JANUARY, 1943 · NO. 1

THE RÔLE OF THE GYNECOLOGIST IN THE FIELD OF CANCER

JANEWAY LECTURE, 1942*

By WILLIAM P. HEALY, M.D.

Gynecological Surgeon, Memorial Hospital; Associate Professor of Obstetrics and Gynecology, Cornell University Medical College

NEW YORK, NEW YORK

I WISH that I were able to express to you in words the depths of my gratitude for the honor your Committee has conferred upon me in choosing me to give the Janeway Lecture this year. My appreciation is increased by the conviction that it must have been done as a token of your friendship. May I say with the utmost sincerity that in no other society in which I have had the privilege of membership have I enjoyed more congenial and happy hours.

As I have nothing of scientific value, or bearing upon pure research to offer to you, I have chosen to talk to you about the gynecologist, including his dusty, if not tarnished past, and to endeavor with a crystal glass, which I trust will not be too opaque, to obtain a glimpse of his future, especially where it touches upon our dual fields of radiation and neoplasms.

What is a gynecologist? From whence did he come and whither does he go?

Gynecology means in a broad sense the study of woman. In a narrow sense it refers to the study and consideration of the diseases peculiar to woman.

In many ways these diseases follow or complicate the act of reproduction, which is the greatest act of a woman's life; indeed, is essentially the reason for her existence.

In the earliest times, in all probability, diseases which afflicted the human body were little, if at all, understood and treatment must have been very sketchy. Injuries and accidents of necessity occurred and were taken care of according to the means and judgment at hand.

Childbirth, however, was something whch was a part of the individual and communal life of every tribe and nation. One can readily understand that individuals or groups of individuals by choice or natural aptitude must have set themselves aside to look after and minister to the woman in childbirth. We therefore can find records dating back to the earliest times indicating that special attention was given to the field of obstetrics and that midwifery as a speciality was gradually developed.

There were no books or treatises upon gynecology but there are many publications of great historic interest dealing with the problems and complications of labor and the diseases resulting therefrom. A brief

* Delivered at the Twenty-seventh Annual Meeting, American Radium Society, Atlantic City, N. J., June 8–9, 1942.

reference to these earlier writings may be of some interest.

In 1678, a system of medicine and surgery was published under the supervision and name of Lazarus Riverius. There were seventeen volumes and it contained the writings and opinions of various individuals of that period. The fifteenth volume was devoted to diseases of women and in the preface the author says, "These are called Womens Diseases which are proper to them only, and come from the defect of that part which is distinct in them from men, viz: the womb: of which Democritus in his letter to Hypocrates said, That it was the cause of six hundred miseries and innumerable calamities. All which diseases we shall speak of in as few words as the dignity of the matter will permit." Among the diseases mentioned in this treatise as coming from the cavity of the womb was cancer.

Gynecology continued to be dwarfed by obstetrics or midwifery until the nineteenth century. In fact, such gynecology as there was up to 1850 was chiefly medical gynecology.

When this country was founded in 1776, Gynecology as a Science did not exist. One hundred years later, in 1876, the American Gynecological Society was founded. Its first President, Fordyce Barker, Professor of Clinical Midwifery and Diseases of Women, Bellevue Hospital Medical College, in his annual address ascribed the elevation of this department of Diseases of Women to the rank of a special science as being due to the development of the vaginal speculum and the uterine sound. He said: "The speculum and the uterine probe, by means of which, chiefly, this department of the profession has been raised to the rank of a special science, had been known and probably were used to a limited extent by a few, as they are mentioned by several writers of the seventeenth century: but no allusion to either of these instruments can be found by any writer in the English language, and it is not probable that a single man in England or America ever made use of either of them until within the past half century."

At this first meeting in September, 1876, it is of interest to note that there is in the published transactions not a single reference to cancer, despite the fact that those present were a carefully chosen group, about forty in number, of the most distinguished gynecological specialists in America.

About the time of the organization of the American Gynecological Society the treatment of cancer of any portion of the female generative tract was indeed in a very sad state. In fact, one European writer published an article in 1876 under the title "Gynecological Cancer, noli me tangere." Another writer, Dr. Lever, in a "Prize Essay on Organic Diseases of the Uterus" said regarding cancer of the cervix, "In my opinion it is useless to remove the diseased portion, however favorable the case may be, unless we can remedy the cancerous diathesis which exists in these patients, and which leads to the redevelopment of the disease in the uterus or in some other distant organ." This indicated an attitude of defeatism which I regret to say still exists and is all too common not only in the public mind but among physicians as well. As a matter of fact in the gynecological literature published during that year, 1876, the treatment of cancer of the cervix was limited largely to the use of such substances as chromic acid, nitric acid, chloral hydrate and tincture of eucalyptus. Safe enough for the physician but useless for the patient.

However, in 1809, the surgical world was startled by the first successful abdominal operation for the removal of an ovarian tumor. It was done by Ephraim McDowell in Danville, Kentucky. This operation aroused much discussion and great controversy. From this point onward American physicians rapidly came to the front in the development of the Science of Gynecology.

Indeed, American gynecologists led the way throughout the entire nineteenth century. In 1845 J. Marion Sims devised his operation for the cure of vesicovaginal

fistula. In 1855, largely through Sims' efforts the Woman's Hospital of the State of New York was opened. One of Sims' associates Thomas Addis Emmet, Surgeon to the Woman's Hospital from 1862 to 1900, was a brilliant and gifted gynecologist who developed the field of vaginal plastic surgery as it still is done today. In speaking of the need for surgical repair of obstetrical injuries to the cervix Emmet says, "Much good was accomplished by demonstrating the existence of lacerated cervix and the close relation of the injury to epithelioma, if it be not the actual cause."

In the final quarter of the nineteenth century, gynecological surgeons gradually grouped themselves into special societies in various parts of this country. So rapid was the progress of these men in surgical technique that they led the way not only in their special field but in surgery of the abdomen, and they were pioneers in introducing new surgical methods and procedures. However, the gynecologists met with much sporadic and at times concerted opposition from the general surgeons who endeavored to limit the field of gynecological activity to obstetrics and medical gynecology. This effort, however, was defeated by the establishment in medical schools of separate chairs of gynecology and in various prominent hospitals throughout the country of separate services devoted to the surgical problems of gynecology.

As I have said before, at the time of the Centennial celebration of the founding of this country in 1876, little of value was being accomplished in the treatment of cancer of the female genitals beyond the application of simple medicinal remedies to the ulcerating lesion. At this time a distinguished gynecologist of Brooklyn, New York, John Byrne, was earnestly advocating amputation of the cervix by the galvanocautery as a method of treatment for carcinoma of the cervix. In a paper recording his observations and describing his method in 1877 he wrote as follows: "In conclusion, I have only to say that of all the means and methods thus far suggested or resorted to for amputation of the cervix uteri, whatever conditions indicating or warranting the same may be, galvanocautery will be found to be infinitely the safest, and in the case of cancer particularly, by far the most thorough and radically curative in its tendency." He had then been doing the operation for eight years and among his reported cases already had survivals for six and seven years.

Byrne continued his work and published his results in papers from time to time befor the American Gynecological Society up to 1896. Watkins, in 1915, said that up to that time Byrne's results in the treatment of cancer of the uterine cervix as given in his statistics were the best that had appeared in the transactions of the Society.

Other gynecologists in this country and in Europe followed Byrne's lead in attempting to eradicate cervical cancer by means of the electric cautery, but the number of favorable results on the whole was small and discouraging. As the principles and technique of abdominal surgery, with special reference to hysterectomy, became better defined and the procedure more successfully accomplished, the efforts on the part of the gynecologists to cure cancer of the cervix or body of the uterus by hysterectomy began to accumulate. Despite the development of extensive radical surgical procedures brilliantly conceived and executed by able gynecologists, the end-results of surgery in the treatment of cancer of the cervix at the end of the last century were not satisfactory. Taneway, in 1919, in a splendid report of his personal experience in the treatment of uterine cancer with radium especially commented upon the difficulties the gynecologist experienced at the beginning of the present century in attempting the Wertheim type of radical hysterectomy for cancer of the cervix, as well as the grave risks faced by the patient, for the mortality rates of different operators were high, even though they varied from 10 per cent upwards to 30 per cent. The post-operative morbidity was distressing and

convalescence slow, usually because of urologic complications.

This was the discouraging situation which faced the gynecologist in his effort to cure the most common type of cancer met with in the female generative tract, cancer of the cervix, in the final decade of the last century.

The Gay Nineties famed in song, music, and the drama, as well as for the gorgeous hats—and bustles of the ladies of those years—left a heritage of much joy and laughter for our subsequent entertainment, but all that came out of that decade was as nothing compared with the product of its final years when mankind was blessed by two brilliant scientific discoveries, that of the X-ray by Röntgen in 1895 and radium by the Curies in 1898. The therapeutic possibilities of both the roentgen ray and radium soon were being widely explored both in the laboratory and the clinic.

Among the earliest lesions subjected to treatment by the rays of these two substances were the neoplasms, both benign and malignant, of the female genital tract. With the exception of a New York general surgeon, Robert Abbe, the pioneer work in this field of therapy in America was done, to a large extent, by gynecologists, as well as a few radiologists.

Dr. Howard A. Kelly, at that time Professor of Gynecology at the Johns Hopkins Medical School, and his associate, Curtis Burnam, took up the study and use especially of radium in 1911 and published their first paper on this subject in 1914. From that time onward they held a leading place in developing the entire field of radiation therapy. Other gynecologists of repute and note who rapidly followed their lead were Clark of Philadelphia; Schmitz of Chicago; Lynch of San Francisco, and Bailey of New York. Many others who have come into the field since have done splendid work and reported large numbers of cases successfully treated by either radium or roentgen radiation or a combination of both.

Today the gynecologically trained specialist holds a very prominent place, as a practitioner, as a teacher and an investigator. He has had an extensive preliminary training; not only the academic and professional training required of all medical graduates, but he has spent a greater part of the first five years following his graduation in apprenticeship and study in general and special hospitals in both obstetrics and gynecology. He is a trained diagnostician and surgeon and is fully conversant with the ills that pertain to the human female. The peculiar nature of his work tends to create an atmosphere of intimate confidence and dependence upon him for advice much greater than exists in other branches of medical science. He has an unusual and continuing opportunity to advise and teach his patients on methods and procedures of health, for often his patients are made up in no small number of those whom he has brought into the world and who continue thereafter to seek professional advice from him. He, in my opinion, occupies a position of grave responsibility and great opportunity to work out problems of prophylaxis and cure in his chosen field. It must be assumed that by his special training and education he should be more competent and alert to the danger signals of cancer than many of his associates. Moreover, he should be fully cognizant of the conditions which may be regarded as antecedent to cancer in his particular field. He should also be more conversant with the physiology and pathology, as well as the endocrinology, of the genital tract and breasts than the general surgeon is.

Probably, so far as the broad field of radiation is concerned, the gynecologically trained specialist assumes a very small rôle. Nevertheless, in his own field he must acquire more than a working knowledge of the indications for and application of radiation methods. The need for this knowledge I think is fully recognized today and the younger graduates are to some extent receiving the necessary training and experience to qualify them. Older men should associate such qualified younger men with

them in their work. Individual initiative is worth while but cannot replace good team work.

Referring to radiotherapy, Burnam says: "It is positively certain that the techniques and fields of application of today will not coincide with those of tomorrow. It has become increasingly important, if not an absolute obligation of the gynecologist to thoroughly familiarize himself with these newer tools, and to study their value as applied to his specialty. Only by this means can follow a fruitful coordination of radiotherapy, operative surgery and other methods of treatment."

The family physician, in the final analysis, is the proper person for patients to report to at regular intervals for thorough physical examination. The gynecologist, like other specialists, endeavors to inculcate this thought in the minds of all patients seen by him.

Experience indicates that few patients seek the specialist; the majority consult a general practitioner first and are referred by him to the specialist or expert if he deems it necessary.

The great difficulty is to establish in the public mind the thought that the individual must not wait for symptoms of illness or disease before arranging for the periodic examination.

Cancer in its incipiency in almost any part of the body is a silent disease and as W. S. Stone has well said, "There are no symptoms of beginning cancer and unqualified statements to that effect must be made not only to the public but to the profession."

The educational requirements which a candidate has to meet today in order to be qualified as a specialist in gynecology or obstetrics are on a very high plane, as indeed they are for specialists in radiology and practically every branch of medicine. Their certification by competent examining boards is all in the interests of the public for it requires one who wishes to qualify as a specialist to spend many additional years in study and training after his graduation in medicine.

As I have said before the very nature of the specialty of gynecology and its twin, obstetrics, tends to establish in the minds of patients a sense of confidence and loyalty toward their physician which, on the one hand, encourages and makes it easier for the patient to obey his admonition to report for examination at regular intervals but, on the other hand, it also places a heavy responsibility upon the physician to make sure that his investigation is thorough and that no dull routine or haste enters into it and nothing must be taken for granted. Sins of omission creep in too easily and must be guarded against.

The obligations of the gynecologist to the public, to his fellow physicians and to his patients in the realm of cancer prevention and cure are very great. His opportunities for constructive work in the prevention and cure of cancer as it occurs in the organs peculiar to the female are unbounded. That cancer is the second greatest cause of death in the United States is well known. The total annual toll of deaths is now nearly 160,000. These figures, of course, do not tell us of the additional thousands now ill with cancer who may still be cured if proper treatment is accorded them, nor of the thousands cured each year through early diagnosis, prompt and adequate treatment. Such facts are too little realized and certainly not appreciated, but these facts are far more pertinent than the total of fatalities. For the dead we can do nothing; for the living we must bend every effort to restore them to health.

It is said that 95 per cent of all cancers occur in men and women over thirty-five years of age, and, according to Wilson of the Harvard School for Public Health, more women between the ages of thirty-five to fifty-four inclusive die of cancer than of any other single disease.

Do we as gynecologists realize that 40 per cent of the fatal cancers in women occur in the uterus and breast? I am afraid not. Yet there is not the slightest doubt that three out of four of those patients could

have been cured if the cancer had been recognized in its early stages and efficient treatment promptly instituted. I think it is no exaggeration to say that since the uterus and the breasts are readily accessible to meticulous examination including inspection, palpation and biopsy study it seems that careful checkups every six to nine months would be adequate to give the protection required. In suggesting to our patients the need for such frequent examinations I like to speak, not of the possibility of finding that a cancer has established itself since the preceding visit, but of identifying and curing any and all of the conditions which if neglected may lead to illness or possibly even to cancer; in other words, to keep the patient in such good health that it would be very improbable that cancer would occur. One would think that abnormal bleeding from the genital tract would arouse enough curiosity or anxiety in a patient to cause her to seek immediately the opinion and advice of a physician. Strangely enough, this striking symptom, in fact the only worth while symptom of cancer of the neck or body of the uterus is all too frequently ignored until the disease has become so firmly established and so widespread that the patient is doomed to die. It is a sad commentary on female intelligence that otherwise well women between the ages of forty and fifty years tend to regard any type of abnormal uterine bleeding as significant of the menopause and fail to consult their physician regarding it. We know and they certainly should be told that in many instances the bleeding is caused not by the menopause but by cancer of the neck of the uterus. Due, we believe, chiefly to this mistaken idea and the resulting procrastination, statistics on cancer of the cervix show that fewer women in the menopausal age survive the disease than in the preceding and succeeding decades.

Here, indeed, is a fertile field for the gynecologist to spread the gospel of truth regarding the significance of abnormal uterine bleeding and thereby save countless valuable lives.

Today it would be difficult to speak of the gynecologist in any rôle without referring to endocrines, endocrine organs, hormones and the possible association or influence of these chemical substances upon the development of cancer. This is a pertinent question in view of the extensive and widespread therapeutic use of hormonal products in recent years, especially those obtained from the ovary and testis. The preparations used are given in concentrated form, often parenterally in large dosage and frequently over long periods of time. Moreover, the symptoms for which they are administered occur in the decades of life in which cancer is most commonly met; therefore, one may say in which the predisposition to cancer is greatest. In view of the great influence which the hormones produced by the endocrine organs are known to have upon the entire body and its functions it is not surprising that much study and research have been directed toward investigating a possible relationship between hormones and the development of cancer.

Much has been said on both sides of this subject. The protagonists are those whose chief interest is in animal experimentation whereas the dissenters are the clinicians who deal with human patients. It may be apropos here to quote Rose who says, "The results of animal experimentation are by no means always applicable to the human subject. What is true in the laboratory is not necessarily true at the bedside."

Of all the endocrine organs the ovary is the only one the internal secretion of which has had a definite influence over the growth of cancer in the experimental animal.

Cancer of the cervix and cancer of the breast have been produced in cancer-susceptible strains of male and female mice by large doses of ovarian hormone given over a considerable period of time. It is also known that when ovarian activity is inhibited by removal or destruction of the ovaries, the growth of such spontaneous cancers in mice is retarded. The results of these laboratory experiments in animals are of deep significance to the gynecologist and

clinician and naturally have led to much cautious clinical investigation and study in an effort to check and double check the possibility of similar occurrences in the human subject. However, it should be stated that an amount of estrogen proportionate to that given the experimental animals could not possibly be given to human beings as it would be much too great for human administration. To date there does not seem to be any authentic instance in which cancer in the human has resulted from the administration of ovarian hormone.

Bittner of Bar Harbor made some interesting observations in his experimental studies with foster nursing in cancer-susceptible mice. He found that the incidence of spontaneous cancer in the litter was markedly decreased if the offspring of cancer-susceptible mothers were nursed during the first twenty-four hours of life by mothers of a noncancer-susceptible strain —a remarkable and intriguing observation.

Greene and Brewer, in their interesting study published last year on "Relation of Sex Hormones to Tumors of the Female Reproductive System" said they "do not believe that there is sufficient evidence to clearly establish that any one factor, such as estrogens, is the sole important etiological agent in the production of malignant or non malignant tumors in the human female. There is insufficient evidence available to lead to the assumption that estrogens as produced in the body or as administered by the physician have directly caused tumor formation in the human."

Nevertheless, in view of the importance of this question of estrogenic influence in the inception and growth of human cancer, I would like to quote the following simple precautions advised by Edward Rose, which to me at this time seems sound and logical.

1. Women who have or have had cancer of the breast or any part of the generative system should permanently avoid pregnancy, no matter how completely the cancer seems to have been cured.

2. Women receiving treatment with any of the natural or synthetic ovarian hormones or hormone-like substances over any considerable length of time should have periodic examinations of the breasts and pelvic organs.

3. In accordance with the suggestion of Bittner . . . women with breast tumors or with family histories of such tumors whether benign or malignant should not nurse their daughters at any time.

Finally, I believe that the gynecologist with his knowledge of the anatomy, physiology, pathology and endocrinology of the generative organs should hold himself equally responsible for a similar, thorough knowledge of the problems of the female breasts, as they are too closely related to be dissociated. He should include them in his therapeutic field and should by training, daily contacts and his wide experience with the problems of the female be better qualified to do so than the general surgeon. Many important developments have taken place in gynecology in recent yers and especially can one note a change in many viewpoints.

Dr. Robert L. Dickinson, in referring to gynecologists, said: "Surgery we have promoted. But, if we be just surgeons, by surgeons we may be displaced." Nothing in my opinion could better indicate the need for a full knowledge of the newer concepts of physiology and endocrinology on the part of the specialist surgeon of whom the gynecologist is the one we are discussing as against the mere mechanical performance of operations.

Let us now briefly consider the gynecological cancer field, our successes, our failures and our problems.

Our armamentarium is all-inclusive for we depend upon surgery, radiation, endocrinology, vitamins, oral, parenteral and intravenous administration of various potent drugs, blood and other fluid preparations.

All of these weapons may be brought into play seriatim in a single case before one has exhausted the possibility of cure for the particular patient.

Consider a woman under forty-five years of age with an operable cancer of the breast. The first step is the well recognized

radical surgical removal of the breast with the underlying muscles and all of the axillary lymphatics. Following this, postoperative irradiation with the roentgen ray is utilized for the entire surgical field as a prophylactic measure against local recurrence of the cancer.

In order to permit the patient to withstand the strain of these two major procedures, operation and irradiation, she will receive intravenous medication in the form of glucose and saline solutions, whole blood or blood protein solutions, according to her needs. Vitamins, liver and other chemical preparations will be taken by mouth.

Finally, recourse to endocrine therapy will be had, if she should be unfortunate enough to develop bone metastases. It is now well known that such secondary growth activity can be largely inhibited, the bone lesions caused to regress and indeed be replaced by new bone structure when ovarian secretory activity is terminated; in other words, by destroying the endocrine function of the ovaries. This can be done by surgical removal of the ovaries or it may be adequately accomplished by roentgen castration with less annoyance to the patient.

Similarly, in the treatment of ovarian cancer, it is imperative that all functioning ovarian tissue be removed surgically or destroyed by irradiation.

This does not seem to be fully understood by all who do pelvic surgery, as far too often because one ovary appears grossly to be normal, and the patient is relatively young; still in the menstruating epoch, the surgeon fails to remove the opposite ovary and the uterus.

This usually condemns the patient to the necessity of another operation in a year or less for the cancer rarely fails to develop in the remaining ovary. At the second operation the surgeon seldom finds conditions as favorable for a cure as they were at the first operation.

Such a conservative point of view on the part of the surgeon must be deplored as it indicates a wrong conception of the behavior of ovarian cancer.

One cannot discuss the squamous cancer arising on the skin or mucous membrane of the vulva without referring to Taussig's splendid studies and his reports of surgical cures of this very malignant lesion.

His pioneer work has demonstrated beyond dispute that once the cancer has broken out, the best method of attack is by means of a radical surgical procedure which clears away the vulva with the primary lesion and all of the lymphatic drainage area to and sometimes beyond both groins.

But this is not the heart of the problem. The gynecologist, by his special knowledge, is in a position largely to eradicate this type of cancer by curing the nonmalignant skin lesions of the vulva which almost invariably have been causing severe annoyance to the patient long before the cancer develops.

These skin lesions can be cured by medical means, by endocrine preparations, by irradiation and finally, if necessary, by minor surgical procedures.

The vulva is a great and fertile field for prophylactic gynecologic measures against cancer.

Unless and until the gynecologist and his co-worker, the obstetrician, educate their patients to the thought that by frequent pelvic examinations the physician will be able to recognize and correct, often by office treatment, the common disturbances of the cervix or neck of the womb, such as endocervicitis, erosions, cysts and small tears, nothing worth while will be accomplished in prevention of cervical cancer. And, not many diagnoses of this anatomical site of cancer in its earliest stages will be made. I say this unequivocally and regardless of whether one believes that local injury, infection or inflammation has been satisfactorily demonstrated as the cause of lesions in the cervix that predispose the cervix to cancer. The fact remains that cancer of the uterine cervix, in our statistics, is almost exclusively a disease of married women, nearly all of whom have conceived.

We owe it to these women to do everything in our power as specialists in women's

diseases to protect them from cancer. It seems to me the way is clear and the path not too difficult.

Once the cancer is established in the cervix it is generally conceded that radiation therapy will cure the favorable cases as permanently as can be accomplished by surgical measures. In the so-called advanced or unfavorable cases, surgery has nothing to offer, whereas radium and roentgen therapy alone, or in combination, not only relieve the patient's symptoms but establish a cure in a rather large percentage of cases.

Cancer of the corpus uteri in general is a postmenopausal disease, and is much more amenable to surgical cure than is cancer of the cervix.

In the patients not surgically operable, adequate irradiation methods will establish a cure in about 40 per cent of such cases. This is encouraging when one considers that the patient had cancer, was probably over fifty years of age and was a poor risk at the start.

In those patients whose symptom is uterine bleeding after the menopause, I would like to suggest, indeed to recommend, a more widespread use of the so-called endometrial biopsy procedure or the suction curette as an integral part of the patient's first examination by the gynecologist. Such an office investigation is feasible in most cases, and if the pathologist's report on the specimen obtained indicates cancer one can, without hospitalization for diagnostic curettage, plan and proceed promptly with treatment for the cancer.

Personally, I have been very much impressed through the years by the frequent association of fibromyomatous uterine tumors with cancer of the uterine body. About 40 per cent of our surgically treated cancers of the corpus have had coincident fibromyomata. I believe this is more than coincidence. By this I do not imply cause and effect, or that the fibromyomata are causative factors in regard to the endometrial cancer. The presence of the fibromyomata in the uterus indicates to me that this particular patient's uterus has tumor growing tendencies and therefore requires close watching.

So impressed have I been by the occurrence of cancer of the corpus after the menopause in association with the larger fibromyomata, 5 cm. or over in size, that I am inclined to advise hysterectomy as a prophylactic measure in such patients. If this is not done, the patient should be instructed to report for examination every six months. Irradiation has little value in reducing the size of fibromyomata after the menopause and should not be used.

Ovarian cancer is the gynecologist's bête noir. It occurs at all ages but especially after puberty. In fact, the most malignant histological types occur in the years immediately following puberty.

This type, common to young women, is extremely amenable to roentgen therapy, and seemingly miraculous cures have resulted in some instances. In general, however, our experience indicates that the primary cancerous ovarian growth or tumor is not radiosensitive and will not disappear after roentgen or radium irradiation.

On the other hand, secondary intraperitoneal ovarian cancer implants, as well as residual disease after incomplete operation, frequently regress or completely disappear under irradiation.

Ovarian tumors as such you can see present puzzling diagnostic problems. It seems to me the important fact to bear in mind is that about 25 per cent of all ovarian tumors are malignant; therefore, a diagnosis of ovarian tumor should mean immediate operation, if the case is operable. One should not delay, for unfortunately there are no symptoms that will permit one to make with accuracy an early diagnosis of ovarian cancer.

The end-results in the treatment of ovarian cancer today are deplorable, whether surgery or irradiation, or a combination of both, is used.

Thus, I come to the end of my lecture and I fear I leave you where we began.

Whither are we going?

PRESENTATION OF THE JANEWAY MEDAL FOR 1942

The Janeway Lecture is usually delivered upon the afternoon of the first day of the annual meeting of the American Radium Society. The medal is presented to the lecturer at the banquet held that evening. The 1942 medal was presented to Dr. William P. Healy of New York by the chairman of the Janeway Lecture Committee, Dr. Douglas Quick, with the following remarks:

This medal is being awarded Dr. Healy for his work in cancer. We are all deeply appreciative of that work and have the utmost respect for it. However, there are other things for which we might hand other medals to Dr. Healy. His work in cancer has been supported by a marvelous background of attainment before he came to the Memorial Hospital to take over the Department of Gynecology.

His long period as Associate Gynecologist to the Roosevelt Hospital very amply fitted him for taking on a special branch of gynecology. Prior to that, in the making of a well rounded gynecologist, he had the fine training of a general surgeon. That probably explains to you why he is never at a loss when he peeks over the brim of the pelvis and sees something wrong in the adjoining territory; he is always able to take care of it.

Many of you may not know that Dr. Healy was at one time Dean of the Faculty of Medicine and Professor of Gynecology to the Fordham University Medical School.

In addition to being, for these many years past, the Gynecological Surgeon of the Memorial Hospital, he is also the Associate Professor of Gynecology to Cornell University Medical School—for all of which we might award him other medals; for his teaching, particularly.

Then, too, his contributions to organized medicine in general have been by no means small. He has been President of the New York County Medical Society and he has done very extensive and real yeoman work in organized medicine in our Community and in our State.

It would be imposing too much upon the good nature of this dinner assembly if I were to attempt an enumeration of the various fine traits in the personal and social side of our Janeway Lecturer and honored guest of this evening. I would probably lose all sense of time.

These are only a few of the little things for which I might offer these extra medals, but I think that a gentleman who has done all of the things that he has and has done them so well must have some special reason back of it all. I think we have to come 'round to the fact that it's just a red-headed Irishman born on the 17th of March, and being born on the 17th of March naturally Patrick had to go into his label.

We have the privilege of honoring not only a wonderful Irishman but a fine professional gentleman and a very loyal friend.

Pat Healy, it gives me very great pleasure to present to you, on behalf of the American Radium Society, the Henry Harrington Janeway Medal.

THE DUST HAZARD IN TREMOLITE TALC MINING, INCLUDING ROENTGENOLOGICAL FINDINGS IN TALC WORKERS

By WILLIAM SIEGAL, ADELAIDE ROSS SMITH, *and* LEONARD GREENBURG

From the Division of Tuberculosis, New York State Department of Health, and the Division of Industrial Hygiene, New York State Department of Labor

FROM time to time the attention of the Division of Industrial Hygiene has been drawn, through compensation claims, to incapacitating fibrosis in talc workers. Since silicate dusts, of which talc is one, have been considered relatively innocuous in the opinion of most authorities (the single exception being asbestos), the occurrence of these cases has naturally raised several questions—the obvious question as to whether this incapacity has resulted from talc exposure alone, and the second more interesting question as to whether industrial hygienists, with few exceptions, have erred in considering asbestos to be the only injurious silicate dust.

In an attempt to answer these questions, the study here reported was undertaken. It consisted of an investigation of the talc industry and an examination of talc miners and mill workers in northern New York State (St. Lawrence County) made, in 1940–1941, as a joint enterprise of the Division of Industrial Hygiene of the State Department of Labor and the Division of Tuberculosis of the State Department of Health.

NATURE OF TALC

Talc is a hydrous magnesium silicate with the formula $H_2Mg_3(SiO_3)_4$ composed, according to Ladoo[13] of about 63 per cent SiO_2, 32 per cent MgO, and 5 per cent H_2O. It is usually a secondary mineral resulting from the alteration of other magnesium silicates or carbonates. While its own silica is present in the combined form, most talcs mined commercially contain varying amounts of such impurities as quartz, calcite, dolomite, iron oxide, etc.

Talc has a characteristic soapy feeling and a pearly lustre. It may be pure white, silvery white, gray or green and, when impure, yellow, brown or reddish. The most common commercial variety is a massive, foliated, or granular type, but it may also occur in a micaceous, or in a fibrous form.

Soapstone is a closely related substance, being essentially an impure talc, and when pulverized it may be used for the same purposes. Tremolite, which is a calcium magnesium silicate, changes over to talc. It may be mined with it and subsequently ground and sold as talc.

GEOGRAPHICAL DISTRIBUTION

The United States produces about 65 per cent of the world's supply of talc, the leading states in its production being Vermont, New York, California, North Carolina and Georgia.

THE INDUSTRIAL USES OF TALC

According to the Minerals Year Book (1938) of the United States Bureau of Mines, the use of talc and soapstone is steadily increasing. Ladoo[13] states that at least 60 different uses for talc have been noted, though most of them are of minor importance. Its value depends chiefly on its usefulness as a filler, inert extender, dusting powder and absorbent. In 1921, according to Ladoo, the marketed, ground talc production in this country was industrially distributed as follows: paper 38 per cent, paint 23 per cent, prepared roofing 18 per cent, rubber 9.5 per cent, textiles 4 per cent, toilet powder 2.5 per cent, other uses 5 per cent.

The other uses for which ground talc is adapted are: as a filler in soap; in foundry facings; in wire-insulating compounds; in dry lubricants; as a filler in cotton textiles; in the dressing and manufacture of leather; as a cleaning and polishing agent for rice, peas, coffee beans, peanuts, etc.; in making colored crayons; as a filler in windowshade cloth; as a dusting agent in making candy, chewing gum, etc.; and as an ingredient of concrete, plastics and insecticides.

Since 1921 there has been a marked increase in its use in the ceramic industry. Fourteen thousand more tons of talc and related materials were sold in 1937 than in 1936 and about 10,000 tons of this increased amount went to the ceramic industry where talc is chiefly used as constituent of glazed wall tile.

REVIEW OF LITERATURE ON THE EFFECTS OF TALC DUST

Experimental Studies. During the last ten years a certain amount of experimental work with talc dust has been reported, but on reviewing this literature most of the inhalation experiments are found to have been of insufficient duration to be helpful in regard to the probable effect of long continued industrial exposure.

In 1931, Haynes[10] included talc in a series of dusts studied for their reactions on guinea pigs. Twelve pigs were dusted two hours daily, except Sunday, for a fortnight. The author saw no sign of pulmonary damage, but found that bronchial and lymphatic removal occurred unusually briskly. He concludes that the substances dissolved from talc are of a low degree of toxicity but sufficiently obnoxious to neighboring tissues to cause the removal of cells containing them.

Stüber,[22] in 1934, studying the cellular response of lymph nodes to various dust suspensions introduced into the lymphatics, found that talc caused no apparent cellular proliferation within the lymph nodes after five days. After 108 days the nodes were still normal and showed no increase in connective tissue.

Fossel,[6] in 1935, reported experiments in which guinea pigs were exposed to the inhalation of talc for one hour daily over a period of eight weeks. No significant tissue changes were seen.

Bethune,[2] in 1935, was able to produce pleural adhesions in cats and dogs by blowing commercial talc into the pleural cavity. Miller and Sayers, quoted below, found that adhesions were produced by injecting various dusts into the peritoneal cavity, but that such adhesions were not related to the subsequent behavior of the dust.

Fienberg,[5] in 1937, having observed granulomas from the surgical use of talc, experimented with the injection of this substance in mice and obtained subcutaneous granulomas in these animals.

Miller and Sayers,[17] in 1936, reported studies in which talc was included among the dusts whose intraperitoneal reaction in guinea pigs was studied. They found that it produced an "inert reaction." That is to say, the injected dust was not absorbed; neither did it initiate a cellular proliferation. In interpreting the significance of "inert reactions" the authors conclude that such dusts should be considered as potentially harmful.

Gardner,[7] summarizing experimental work on silicate dusts at the Saranac Laboratory said, at the Fourth Saranac Laboratory Symposium on Silicosis (1939), "a few silicates like true talc . . . and some of the clay minerals have provoked chronic inflammation (of the lungs) but this reaction has tended to retrogress after several months. No progression to a stage of true fibrosis has been observed within periods of one to two years and there is no indication that the progression will occur."

Policard,[20] in 1939, reported an experiment in which he dusted white rats with foliated, industrial talc three hours a day for twelve days. The intensity of the exposure was high. He found that the dust was irritating to the upper respiratory tract and produced a marked dyspnea. In the lungs of animals sacrificed two and six days after inhalation began, he found dilatation of bronchi, acute emphysema, and exudative alveolitis. Many animals died spontaneously with pulmonary congestion and foci of bronchopneumonia. The short duration of the experiments did not permit any conclusion concerning the possibility of pulmonary fibrosis.

McCormick and Ramsey,[15] in 1941, reported postoperative, peritoneal granulomatous inflammation caused by talc in 2 cases.

Schulz and Williams,[21] in 1942, injected intra-

peritoneally in guinea pigs a series of seven commercial talcs with different silicate-carbonate ratios. Animals were sacrificed at intervals ranging from ten days to fifteen months. In all cases, the pathological histology showed the holding of talc particles in a local area by phagocytic cells of the macrophage and giant cell type. Progressive fibrosis was not found. The fibrosis which occurred was only enough to hold and limit the space for storing the foreign material. The greatest amount of fibrous tissue developed in the presence of the two talcs which contained the least carbonate and the most talc and tremolite respectively.

Clinical Reports. Talc fibrosis as an occupational disease has received attention in this country only within the past ten years, and until the studies of Dreessen and DallaValle, discussed later, extremely few talc workers had been studied anywhere.*

Policard[20] says that it was in 1896 that the question of the action of industrial talc dust on the human lung was first considered. At that time a pathologist of Nuremberg, Thorel, published the results of the pathological examination of the lung of a tuberculous woman patient of forty-four years, who had worked for many years in soapstone dust. According to Policard, Thorel demonstrated the presence of cells containing soapstone dust in the cavity and walls of certain alveoli and the existence of formations, more or less nodular, resulting from the accumulation of cells filled with talc. Other nodular formations of a tuberculous nature were present, and Thorel pointed out a combination of tuberculous and pneumoconiotic lesions.

In 1915, according to Policard,[20] Hayburst stated that work in talc dust favored and exaggerated tuberculosis, but the basis for this opinion is not known.

Zanelli, in 1931, quoted by Teleky,[23] came to the conclusion that talc dust, though belonging to the family of silicates, ought to be considered dangerous and likely to produce typical pneumoconiotic lesions.

Merewether[1] in 1933, reported the cases of 11 rubber tire workers, exposed from ten to thirty-two years to French chalk, a fine granular variety of talc dust, who showed diffuse interstitial fibrosis by roentgen examination without clinical evidence of anything more than a peribronchial increase in fibrous tissue. Thirteen additional workers, with exposures of from four and one-half months to forty-eight years, were examined and reported upon the following year[1] confirming the original findings.

In 1933 a report was made by Dreessen[3] of examinations of a number of workers in silicate dusts, including 57 men exposed to tremolite, a hydrous calcium magnesium silicate containing no free silica.

The findings in this group were as follows: more fibrosis than usual 67 per cent, first stage pneumoconiosis 26 per cent, second stage pneumoconiosis 2 per cent, normal lungs 5 per cent.

Dreessen described the first stage pneumoconiosis as similar to that produced by cement dust; "softer" than that resulting from silica dust, a "diffuse, fine, generalized fibrosis . . . chiefly confined to the lower two-thirds of the lung fields."

In 1935 the same author, together with DallaValle,[4] reported on the effect of exposure to dust in two Georgia talc mills and mines. The dust involved was, again, a calcium magnesium silicate containing no free silica. It was present in excessive amounts, over one and one-half billion particles per cubic foot in some operations, the particle size averaging less than 1 micron. Sixty-six workers were examined. Among these, 22 (33 per cent) showed pneumoconiosis, 8 in stages two or three. The conclusion was reached that exposure to talc dust was either "too severe" in the Georgia study, or that this talc was a more dangerous dust than that previously studied. No particular relationship between talc exposure and tuberculosis was demonstrated.

Middleton,[16] in 1936, referred to an unpublished case of Cunningham's in which pneumoconiosis was found in a talc grinder who had been employed for nine years. He also mentioned an autopsy by Sand in 1910 on a woman exposed to talc dust in which "not much reaction" was found.

In 1938, Nuck and Szczepanski[19] reviewed the literature on talc fibrosis and added several cases of their own. They concluded that this type of pneumoconiosis resembled asbestosis more than silicosis.

At the International Conference on Silicosis

* Since this report was written, Porro, F. W., Patton, J. R. and Hobbs, A. A., Jr. (Pneumoconiosis in the talc industry. Am. J. Roentgenol. & Rad. Therapy, April, 1942, *47*, 507–524) have described pneumoconiosis in 15 tremolite talc workers with a fatal termination in five.

at Geneva in 1938,[12] Riddell reported the results of the examination of 37 workers engaged in grinding talc ore. Thirteen showed fibrosis resembling silicosis.

Gardner on the same occasion[12] said that of 300 films of talc workers which he had examined about 50 showed some evidence of pulmonary reaction which in 17 suggested nodulation.

From a survey of the literature it appears that while experimental studies have hitherto been inconclusive, clinical studies have tended to indicate that talc dust is capable of producing injurious pulmonary changes.

COMPENSATION CLAIMS FOR DISABILITY DUE TO TALC DUST IN NEW YORK STATE

The cases which originally drew the attention of the Division of Industrial Hygiene to disability resulting from exposure to talc dust are summarized below. Six such cases have occurred during the past few years. One originated in the manufacture of talcum powder; one in the shoe industry, and 4 of them in talc mining and milling. In one case (Case v) there had been significant previous exposure to dust probably containing free silica. Five of the 6 cases were fatal. In 5 cases, summaries are available as follows:

CASE I. Aged sixty-three. The claimant had worked for twelve years operating a talcum powder mixing machine not provided with exhaust ventilation for dust control. The talc used was found by the Division of Industrial Hygiene to contain less than 0.5 per cent of free silica. The dust concentrations at this work ranged from 13.9 to 34.8 million particles per cubic foot.

For three or four years before quitting the job, the claimant had complained of cough with expectoration. *Examination of the lungs* showed moist râles at the bases. The vital capacity was 2,500 (normal estimated as 4,000).

Roentgen examination of the lungs showed an increase of bronchial markings in the lower and middle fields with areas of increased density resembling lipiodol or calcific deposits in both midlung fields.

A *diagnosis* was made in hospital of emphysema and chronic bronchitis with acute exacerbation.

CASE II. Aged forty-four. For twenty-t years the claimant had worked as a "bed last in a shoe factory. White shoes were manuf tured during about five months of the yea at these times he used talc freely, dusting it the shoes to prevent soiling of the white leath The powder used was analyzed by the Divis of Industrial Hygiene and found to contain free silica.

For seven years before quitting work he co plained of cough, dyspnea and increasing we ness. His condition finally necessitated hospi treatment.

Physical examination showed the presence dyspnea, cyanosis and clubbing of the fing Examination of the lungs revealed dullness both sides with diminished fremitus and bre sounds.

Roentgen examination of the chest shov marked, confluent, hazy mottling with nodu densities uniformly distributed. The right v tricle was hypertrophied (cor pulmonale).

The *diagnosis* was chronic pulmonary fibr and emphysema. The case terminated fat nine months after admission to the hospital

CASE III. Aged forty-nine. The claimant l worked as a talc miner for fifteen years w eight months' exposure in other mines ten ye previous to his talc exposure. His illness be five years before death with shortness of bre and a productive cough. He quit work t years after the onset of symptoms because increasing weakness, and was admitted t sanatorium.

Physical examination showed an emacia individual who looked chronically ill. The v capacity was 1,800 (normal estimated as 3,0 The lungs showed dullness over the mid thirds, râles above second rib anteriorly, posteriorly throughout. Five specimens sputum were negative for the tubercle bacill The temperature was normal.

Roentgen examination showed extensive, lateral fibrosis with infection, probably tuber lous, and this was the diagnosis.

CASE IV. Aged thirty-seven. For twenty- years the claimant had worked in talc mines mucker, driller and foreman. For two ye before quitting work he had noticed cou shortness of breath and pain in chest. He easily fatigued. These symptoms caused h to enter a hospital for treatment.

Physical examination revealed no lung normalties but showed cardiac hypertrop hypertension and evidence of nephrosis.

Roentgen examination of the chest showed fine nodulation through both lung fields below the fifth posterior rib, more marked in the central lung field, an increase in hilum shadows and cardiac hypertrophy.

The clinical diagnosis was early silicosis with probable infection, hypertensive disease and severe nephrosis.

The case terminated fatally.

Case v. Aged fifty-two. The claimant had worked in talc mines for seventeen years with a previous exposure of ten years in zinc and iron mines. Illness began six years before death with cough and dyspnea. Following the initial symptoms he developed pain in chest and hemoptysis and sought hospital treatment.

Physical examination showed an emaciated individual, appearing chronically ill. The fingers were slightly clubbed. The chest expansion was limited. Examination of the lungs showed dullness on the right below the seventh spine with râles and diminished breath sounds. The sputum was positive.

Roentgen examination showed a fine miliary type of increased density on the left, a mass of increased density in the right middle lung field with evidence of excavation, and heavy fibrosis at the right base.

The clinical diagnosis was probable silicosis, complicated by tuberculosis.

Death occurred twenty-one months after admission to the hospital.

Report of a Study of Talc Miners and Millers in St. Lawrence County, New York

Scope of Study. In the course of this investigation studies of operations and dust concentrations were made by engineers of the Division of Industrial Hygiene in three talc mines and five talc mills. Two hundred and twenty-one men from seven plants received an initial roentgen examination. In the case of 28 of these individuals, who showed positive lung findings, a follow-up examination was made at the end of ten months which included a second roentgenogram, a medical history and physical examination of the chest, and a detailed occupational history.

The roentgen examinations were made with a 200 milliampere machine mounted on a truck belonging to the Division of Industrial Hygiene.[11] Patterson high speed screens were used, and exposures were made at a 60 inch distance and with an exposure time of one-tenth of a second.

Type of Talc Involved. The type of talc produced in St. Lawrence County is of the fibrous variety known as asbestine. It is noted for its clear whiteness and is used chiefly as an ingredient in the manufacture of paint and tile. With it is found tremolite —calcium magnesium silicate ($CaMg_3(SiO_3)_4$)—a similar appearing mineral occurring in a fibrous or asbestiform state which in the course of time changes over to talc. Gardner[8] reports that anthophyllite, another fibrous silicate, is also present in the talc deposits of the St. Lawrence County region.

Analysis of representative samples of talc from two of the mines in the region, submitted by one of the mining companies, shows the following composition:

Analysis	*Sample A*	*Sample B*
Total silica*	68.24	57.50
Calcium oxide	2.72	5.24
Aluminum oxide	—	.27
Iron oxide	—	.17
Manganese oxide	—	.16
Carbon dioxide	—	.38
Magnesium oxide	24.51	30.20
Calcium carbonate	0.23	—
Sulfur trioxide	trace	—
Ignition loss	3.65	5.13
	99.35	99.05

Free silica content. The free silica content of commercial talc as found in industrial use is very low. Schulz and Williams[21] report that of 51 samples analyzed quartz was not found in 25; traces of quartz only were present in 25; while one sample showed a quartz concentration of 3 per cent. The free silica content of the talc in the mills and mines included in this study was likewise found to be low. Six samples from two talc mines, taken and analyzed by chemists of the Division of Industrial Hygiene, showed 1 per cent or less of free silica. Two of these samples were taken from long standing accumulations of waste rock; two were

* Includes both free and combined silica.



FIG. 1. Tremolite talc. Note bundle-like arrangement of fibers. (Magnification 2,500×.1 inch = 10 microns.)

from recent three- and four-day-run waste accumulations; and two were from collections of rock destined for the mills. Six samples of ground talc from several mills were also analyzed and in each case the silica content was found to be less than 1 per cent. Dreessen[3] also reported little or no free silica in the composition of the talc in this region.

Gardner,[8] on the other hand, found amounts of quartz ranging from 12 to 20 per cent in mineral samples from two mines in this area. It is difficult to explain the marked difference between Gardner's findings and those of Dreessen[3] and ourselves, except upon the supposition that Gardner's samples included some of the quartz-bearing stratum overlying the talc deposit proper. That such high percentages are not representative, however, is shown by the



FIG. 2. Tremolite talc. Note straight needle-like fibers. (Magnification 2,500×.)

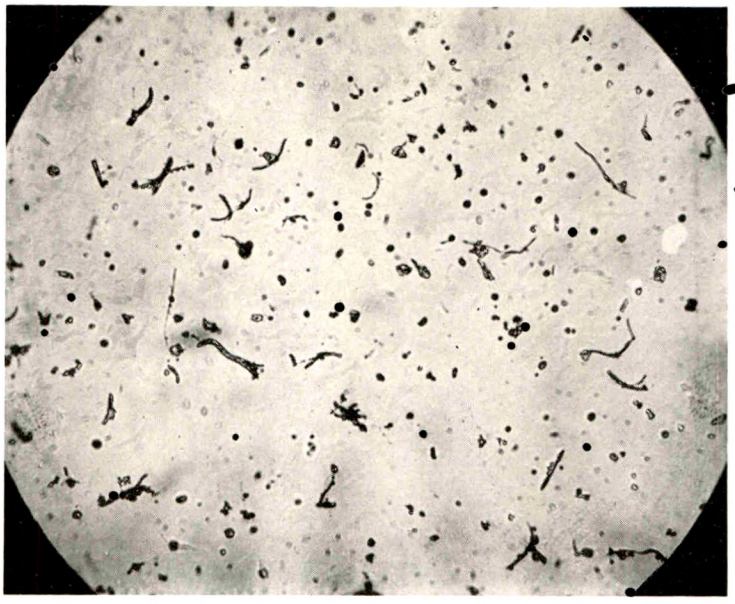


Fig. 3. Asbestos. Note curving tendril-like fibers. (Magnification 2,500×.)

fact that material from the mills where all rock is mixed and crushed showed low quartz percentages both in Gardner's studies and our own.

Microscopic appearance. Photomicrographs of talc dust from St. Lawrence County show that it tends to occur in oblong or squarish particles made up of parallel fibers (Fig. 1) which splinter off into sharp spicules (Fig. 2). Its microscopic appearance differs from that of asbestos (Fig. 3) in that asbestos fibers tend to be curved and tendril-like in form, whereas those of talc appear straighter and needle-like in structure. Tremolite talc fibers are also much shorter than those of asbestos. In this study their maximum length was approximately 15 microns. Asbestos fibers, on the other hand, may attain a macroscopic length. In interesting contrast to both tremolite talc and asbestos are the flake-like particles of mica dust (Fig. 4), another

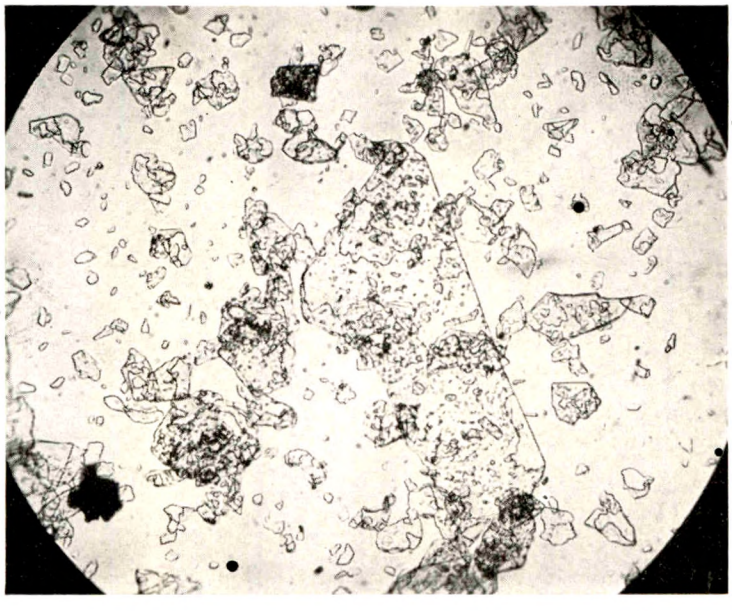


Fig. 4. Mica. Typical mica particles, showing the very thin plate-like structure. (Magnification 2,500×.)

magnesium silicate, and the granular particles of granite dust (Fig. 5), a combination essentially of quartz and feldspar.

Description of the Industry

Talc Mining

Mining operations. Talc ore is obtained by underground mining. Inclined shafts are used with headings to various depths down to about 1,100 feet. The talc occurs in compact, homogeneous seams, so that contact with hard rock is limited to that incurred on entering a seam. Once a seam is entered there is no exposure to anything but talc until it becomes necessary to enter another seam. Since seams may be worked for years, the amount of drilling in hard rock is very small compared with the amount of drilling in talc.

The headings are mined by drift drilling, blasting, and hand or machine mucking. Raising and stoping are resorted to, to obtain the ore from pockets. All drilling is done dry since every precaution must be taken to avoid wet ore which cannot be milled and is wasted. Drilling crews of one or two men are used, the drillers doing their own blasting. The ore is then mucked as it is required by the mills. It is loaded into muck cars and pushed along the haulageways to the shaft where it is dumped into a skip, hoisted to the surface, and dumped into railroad cars or trucks for shipment to the mills. Each mine employs fifteen to seventeen men underground.

Dust exposure in talc mining operations. The problem of the best method of control of the dust in talc mines is one which is receiving the attention of the Division of Industrial Hygiene at the present time. Very little dust control was found in the three mines studied. Some attempts had been made to remove the dust during drift drilling by means of small, home-made, portable units, but relatively few of these were in actual use during drilling operations. The drillers wore respirators.

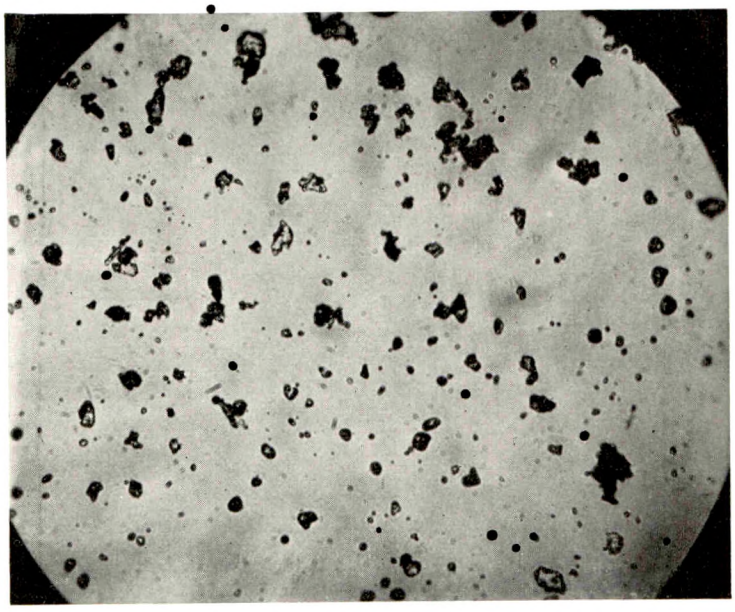


FIG. 5. Granite. Shows lack of form usually found in silicate and silica particles. (Magnification 2,500×.)

Twenty-two dust samples were taken with a midget impinger at various operations and situations. These were counted within ten hours of the time of sampling by means of the low power, light field technique, and gave the results shown in Table 1.

The dust counts where no exhaust device was used gave average dust concentrations as follows: for drilling 1,350, for stoping 1,290, for mucking 35, and in the general air, 17 million particles per cubic foot.

Talc Milling

Milling operations. The milling processes in all five mills were found to be essentially alike. The ore is shipped to the mills in railroad cars or trucks and is dumped into chutes leading to a jaw crusher. From the jaw crusher the talc, in most mills, passes through disc or roll crushers, or both, before entering rotary or trommel screens. After passing the screens, the talc is stored in garners before the final milling operation which takes place in pebble mills. The final separation of the finely ground talc is accomplished with air separators, from which the material passes to garners which feed bagging machines.

The bagging machines utilize open top bags, or sacks, which fit loosely onto the discharge spout of the machines. Hand scoops are used to add or remove talc from the bags to obtain accurate weight. The greater percentage of material is bagged in

TABLE I

DUST CONCENTRATIONS IN TALC MINES

Operation	Mine	Dust Count (million particles per cubic foot)	Remarks
Drilling	A	200	"Upstream" of drill. Rate 2′ per minute
		300	"Downstream" of drill
		75	3′ "upstream." Using exhaust
		110	Same as above. Breathing level of helper
		600	Exhaust off
		2700	Exhaust off. Breathing level of helper "downstream"
		5000	Exhaust of dust collector
		1500	Same as above; 3 minutes after drilling stopped
		150	General air stream
	B	65	"Upstream" air movement 50′ per minute
		265	Same as above. Air turbulent
	C	90	Dead end drift
		300	Just off main airway
		16	Main airway
		100	Breathing level driller, top of open stope
Stoping	A	4000	Dead end stope. No air movement
	B	760	Top of dead end raise
Mucking	A	40	Bottom of stope, drilling at top
		50	Same as above
		6	Top of pile, mucking only operation
	B	35	"Downstream" of mucker
		24	Same as above

TABLE II

DUST CONCENTRATIONS IN TALC MILLS

Operation	Mill	Dust Counts (million particles per cubic foot)	Average Dust Concentration (million particles per cubic foot)
Crushing-jaw crusher	1	20	
	2	41.5	
	3	76.5	46
Crushing-disc or roller crushing	1	22	
	2	79	50
Pebble milling	1	32	
		46	
	2	106	61
Bagging—paper	1	141	
	2	190	
	4	160	163
Bagging—burlap	1	120	
	3	73.5	
	5	87.5	93
General air cylinder room	1	48	
	3	85	
	4	78	
	5	77	72
Separator room	4	58	
	5	67.5	62
Manual handling	1	215	

50 lb. paper bags, while some is shipped in larger burlap bags. The operators of the bagging machines stack the filled bags on hand trucks and wheel the loaded trucks into railroad cars or automobile trucks for shipment, or into the warehouse for storage.

Dust exposure in talc milling operations. Dust control in the various mills is confined chiefly to the bagging machines and pebble mills. Some control is also used in several mills at the crushers and material transfer points. Dust samples were taken throughout the mills using the technique already described. The samples were taken at the breathing level of the workmen in locations where men are usually stationed.

Table II shows the concentrations found at various points throughout the mills. Manual handling of the talc produces concentrations in excess of those found at other operations but, fortunately, there is little manual handling during normal procedure.

The dustiest operation, other than manual handling, is that of paper bagging where the average dust concentration for three mills was found to be 163 million particles per cubic foot.

TABLE III

FIBROSIS IN TALC WORKERS, BY LENGTH OF EXPOSURE

Years Exposed	All Workers Examined	Cases of Fibrosis		
		Number	Total Fibrosis Cases per cent	Exposure Group per cent
5	82	—	—	—
5–9	32	—	—	—
10–14	47	8	25.0	17.0
15–19	33	13	40.6	39.4
20–24	10	2	6.3	20.0
25–29	9	3	9.4	33.3
30–39	6	5	15.6	83.3
40–49	1	—	—	—
50–59	1	1	3.1	100.0
Totals	221	32	100.0	14.5

Roentgen Findings

Fibrosis

Incidence. In recording pulmonary fibrosis among talc workers, those with slight or even moderate degrees of fibrosis were disregarded, and only those cases included in which a marked degree of this condition was present.

Upon the initial roentgen survey in 1940 fibrosis was found in 32 of the 221 men examined, giving a rate of 14.5 per cent. The distribution of these cases according to length of exposure is shown in Table III.

It will be seen that no cases occurred in workers with less than ten years' exposure. The 32 cases of fibrosis were all found among the 107 men who had worked in talc for ten years or longer, giving an incidence rate for this group with ten years or more of employment of 29.9 per cent. Of the 8 men who had worked thirty or more years in talc, 6 showed fibrosis (74 per cent).

To make clear the fact that talc is a fibrosis-producing dust the distribution of cases of fibrosis, according to age, in talc workers and in a group of carpet factory workers previously examined by the authors, is shown in Table IV.

Fibrosis was present in only 2.5 per cent of all carpet workers, and in 4.9 per cent

TABLE IV

FIBROSIS IN TALC AND CARPET WORKERS, BY AGE

Age	Talc Workers			Carpet Workers		
	Number examined	With fibrosis		Number examined	With fibrosis	
		Number	Per cent		Number	Per cent
Less than 20	4	—	—	6	—	—
20–29	71	1	1.4	57	—	—
30–39	72	7	9.7	61	1	1.6
40–49	41	7	17.0	57	1	1.7
50–59	17	9	52.9	49	4	8.1
60–69	13	6	46.1	33	—	—
70–79	3	2	66.6	3	—	—
Totals	221	32	14.5	266	6	2.5

of those fifty years of age and older; while it was present in 51.5 per cent of talc workers in this age group.

Ten months after the original roentgen study, a second visit was made to the same plants for follow-up examinations of selected cases. At this time occupational and medical histories were taken and chest examinations were made. From the occupational histories it was possible to eliminate those men who had previously been exposed to other types of siliceous dust. In this way a group of 18 cases showing marked fibrosis was defined in men who had not worked in any other dusty industry and whose only significant dust exposure, therefore, had been to talc.

Signs and symptoms. Fifteen of the men showing fibrosis worked in the talc mills; 3 were miners. The proportion of mill workers to miners in the entire group, however, was approximately 2.3 to 1, showing that fibrosis was relatively more prevalent among millers than miners. With one exception, the men with fibrosis were all forty years of age or older and had been exposed to talc dust, as noted above, for at least ten years.

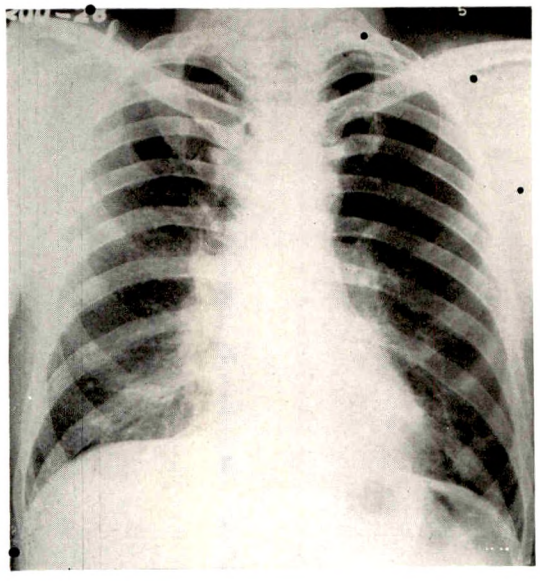


FIG. 6. Case 200-28. Aged forty-six. Began working at age of fifteen. Woolen mill six years; talc mill worker twenty-five years. Complains of cough, shortness of breath, pain in chest, fatigue. *Physical examination:* Chest expansion 1⅛ inch, respiration 28, breath sounds diminished. Clubbing of fingers. *Roentgen examination:* Shows a very fine, granular fibrosis on a diffusely hazy background. The hilar nodes are thickened.

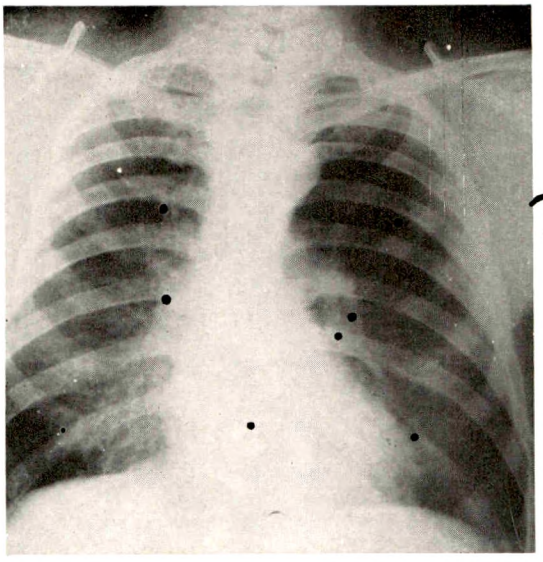


FIG. 7. Case 198-3. Aged fifty-four. Began work at age of fifteen. Farmer sixteen years; telephone linesman seven years; talc mining sixteen years. Complains of productive cough and dyspnea. *Physical examination:* Chest expansion 1 inch. Nails curved. *Roentgen examination:* Shows enlargement of the hilar nodes, and exaggerated linear markings at the right base. There is also a fine, generalized, diffuse fibrosis having a granular appearance.

Thirteen of the 18 had one or more symptoms referable to the lungs. Ten complained of dyspnea; 7 of chronic cough and 3 of pain in the chest. In addition, 5 complained of excessive fatigue.

On physical examination, all 18 showed limited chest expansion. Thirteen showed abnormal lung signs and 13 showed curving of the nails or clubbed fingers. In one case cardiac hypertrophy was observed, and in one auricular fibrillation.

The general appearance of the group struck the examiners as being distinctly different from the appearance of the usual group of first and second stage silicotics who are still able to work. The latter usually present a robust appearance. A substantial number of individuals in such a group are

NY 5 Ca D-24 395.

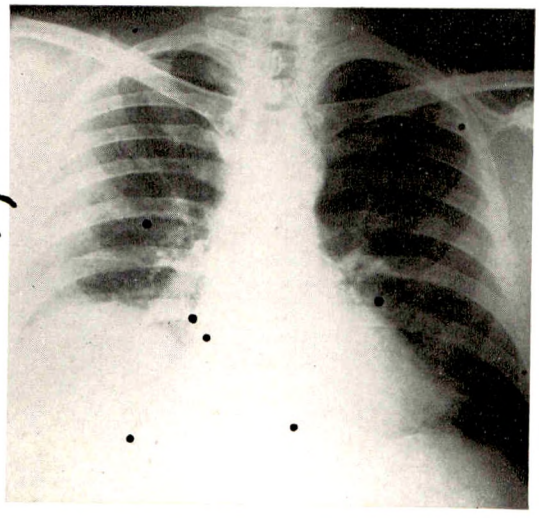


FIG. 8. Case 197-38. Aged fifty-five. Began working at age of fourteen. Talc mill laborer and foreman forty-one years. Complains of fatigue. *Physical examination:* Chest expansion 1¾ inches; clubbing of fingers. *Roentgen examination:* Shows marked elevation of right diaphragm with obliteration of the costophrenic sulcus. On the left leaf of the diaphragm is a deposit of opaque material. Both lungs show a fine, granular fibrosis.

likely to be overweight. This was not the case with the talc workers who showed fibrosis. None of them was overweight, but on the contrary they tended to present an undernourished and drawn appearance. It was the impression of the examiners, also, that dyspnea was unusually pronounced in relation to the extent of the fibrosis seen in the roentgenograms.

Roentgenographic characteristics. The type of fibrosis seen in these roentgenograms is very fine and diffuse, showing in many cases an appearance of soft haziness to which the term "ground glass," used in describing certain cases of asbestosis, can very well be applied. This is illustrated in Figures 6, 7, and 8. In a number of cases there is in addition a distinctly granular appearance (Fig. 7), and in some nodulation (Fig. 9 and 10) which might be confused with silicosis. In certain films soft conglomerations also occur (Fig. 9 and 11).

The fibrosis in these cases tends to be somewhat more marked on the right side, and in the mid-lung fields and bases as seen in Figures 7 and 9. The hilar nodes show a slight or moderate increase in density. Evidence of obliterative pleuritis and emphysema is also present in some cases. In a few instances (Fig. 7 and 11) a blurring or "shagginess" of the cardiac outline is noticeable.

Tuberculosis. In the total group of 221 talc workers there were 29 (13.1 per cent) cases of primary healed tuberculosis; 6 (2.7 per cent) cases of healed reinfection type tuberculosis and 5 (2.2 per cent) cases which were considered, on the basis of the roentgen appearances alone, to show clinically significant tuberculosis.

The incidence of healed primary and reinfection type lesions is not remarkable in any way, being similar to that found, in general, in other industrial groups. The incidence of clinically significant tubercu-

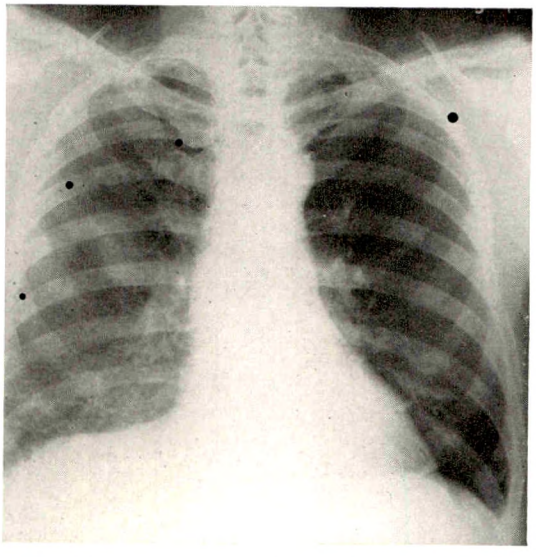


FIG. 9. Case 196-3. Aged sixty-eight. Began working at age of sixteen. Farmer twenty-three years; carpenter six months; talc mill laborer and repair man twenty-nine years. Complains of dyspnea. *Physical examination:* Chest expansion 1½ inches, respiration 24, râles both bases. *Roentgen examination:* Shows a diffuse, finely nodular fibrosis throughout both lungs. There is emphysema at the left base. There is apparent thickening of the pleura at the right base with several horizontal shadows in this region. There is also an area of increased density extending from the second to the third interspace on the right, and shadows at both apices suggesting possible reinfection tuberculosis.

losis (2.2 per cent) is slightly higher than is found in most industrial groups, the average rate found for this condition being about 1.2 per cent. Among the 5 individuals with clinically significant tuberculosis 3, between the ages of thirty and fifty, showed minimal lesions; one, forty-five years of age, showed moderately advanced lesions and one, sixty-four years of age, showed what was interpreted to be far advanced atypical tuberculosis. Among the 18 cases of fibrosis in men exposed only to talc clinically significant tuberculosis appeared to be a complicating feature in 3 cases (16.6 per cent).

Talc plaques. A most interesting finding in this group of talc workers—interesting because, to these investigators, it was new—was the presence in 14 instances (6.3 per cent of the 221 talc workers originally roentgenographed) of what appeared to be deposits of opaque material on various pleural surfaces. These deposits, or plaques, are seen on the visceral pleura, including the region of the diaphragm, and occasionally the pericardium (Fig. 8, and 13 to 17). Lateral and oblique views indicate that their location is definitely at the periphery of the lung, not involving the parenchyma (Fig. 17).

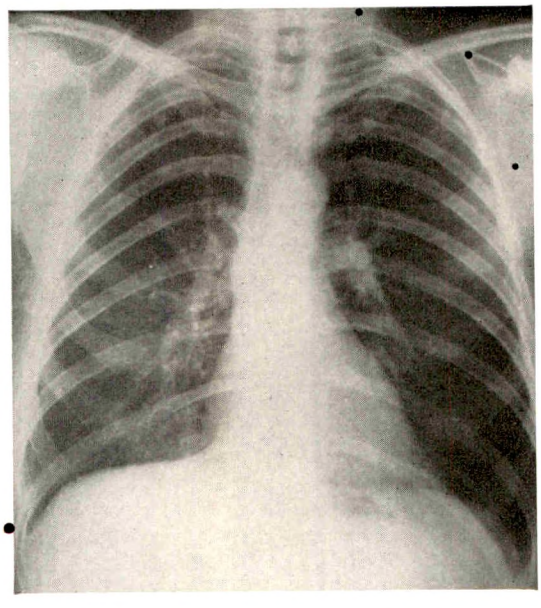


Fig. 10. Case 197-8. Aged forty-nine. Began working at age of fourteen. Talc mill laborer thirty-five years. Complains of dyspnea, pain in chest, fatigue. *Physical examination:* Chest expansion 1¾ inches. Nails curved. *Roentgen examination:* Shows diffuse finely nodular fibrosis with soft shadows suggesting bilateral, clinically significant, apical tuberculosis.

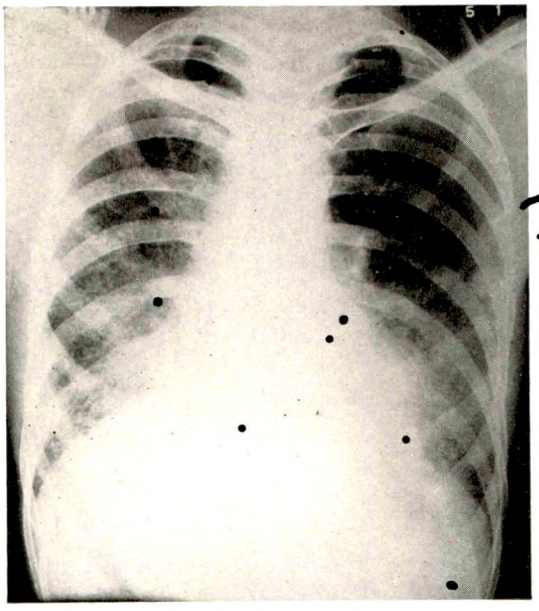


Fig. 11. Case 201-10. Aged forty-nine. Began working at age of sixteen. Farmer seven years; talc mill laborer and foreman twenty-six years. Complains of productive cough, dyspnea and fatigue. *Physical examination:* Chest flat, expansion limited, dullness at apices, otherwise hyperresonant. Râles throughout, most marked at bases. Respiration 22; pulse 116. Heart negative. Clubbing of fingers. *Roentgen examination:* Shows a fine, soft mottling over both lung fields, more pronounced at the bases. In addition, in the third left interspace near the periphery is a round homogeneous area of increased density about 2 cm. in diameter.

In size the plaques vary from a single, linear-appearing deposit of a few centimeters in length in the region of the diaphragm (Fig. 8 and 12) to massive deposits bizarre in shape, extending over a large part of the lung fields (Fig. 14, 15, 16 and 17). They are characterized not only by irregularity of shape, but by marked irregularities in degree of density also, and by the sharpness of their borders. In this series of films the development of these plaques can be traced from small, light, scarcely noticeable deposits to the extensive opacities described.

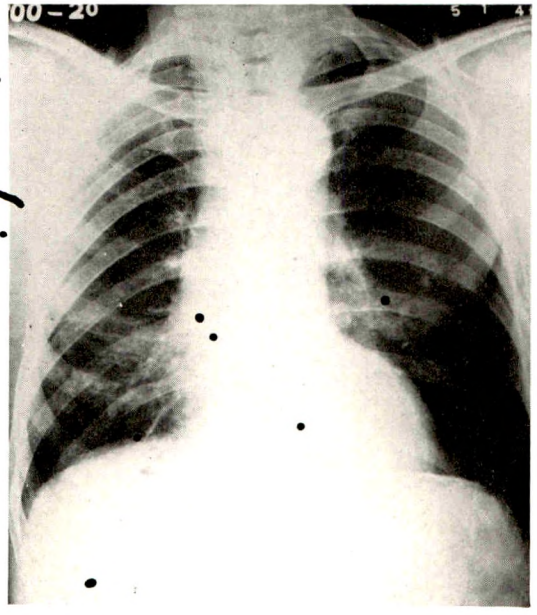


FIG. 12. Case 200-20. Aged sixty-three. Began working at age sixteen. Fireman three years; farmer eight years; talc mill laborer and repairman thirty-nine years. Complains of dyspnea and fatigue. *Physical examination:* Lungs hyperresonant. Heart slightly enlarged to left, rate irregular. Clubbing of fingers. *Roentgen examination:* Shows deposits of opaque material on the left diaphragmatic dome; marked emphysema at the left base. Both lungs show diffuse, granular fibrosis with irregular patchy shadows at right base and left midlung field.

It should be noted that roentgen appearances similar to the plaques herein described were apparently seen in Case 1 where mention is made of areas of increased density resembling lipiodol or calcific deposits in mid-lung fields. Similar appearances have also been noted in another group of workers who were exposed to talc dust in the making of material for electrical insulation.

So far as can be ascertained, these deposits bear no relation to any history of previous infection since they occur both with and without such a history. Nor are they necessarily associated with other pulmonary pathology. The underlying lung tissue may or may not show fibrosis. There is no associated enlargement of the hilar nodes in cases showing plaques without fibrosis.

An analysis of the group of 14 talc workers who showed these deposits revealed the following facts: Their ages ranged from thirty-five to seventy-seven years and their exposure in the talc industry from four to fifty-two years. Ten were mill workers; 4 were miners. Only one individual gave a history of having had pleurisy. None had had empyema. In 5 instances no lung pathology other than the plaques was noted. A marked degree of fibrosis coexisted in 7 cases. Evidence of clinically significant tuberculosis was seen in one case and of primary healed tuberculosis in another case.

No symptoms or physical signs attributable to these deposits could be identified,

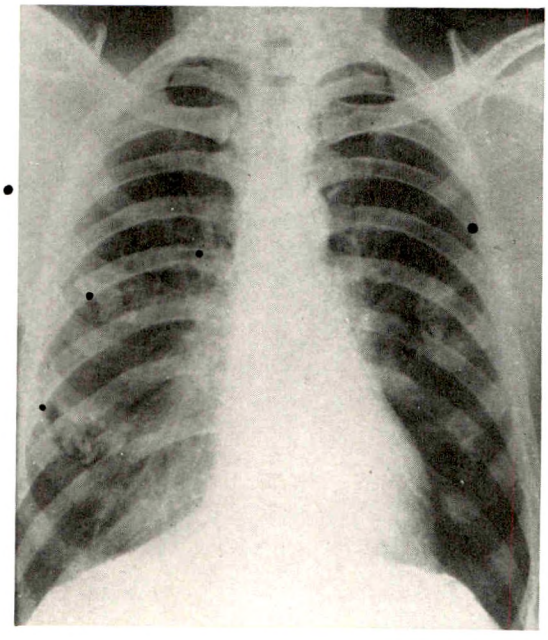


FIG. 13. Case 201-5. Aged fifty. Began working at age of fifteen. Farmer seventeen years; repairman in talc mill eighteen years. Complains of cough. *Physical examination:* Lungs show diminished breath sounds throughout, especially on right. Heart: systolic murmur at apex. Pulse 120. Clubbing of fingers. *Roentgen examination:* Shows a soft, diffuse, very finely nodular fibrosis throughout both lungs. In addition, there are irregular, sharply defined deposits of opaque material in both middle and lower lung fields. (Lateral and oblique views show that these plaques are located near the periphery.) There are similar deposits on both diaphragms and in the region of the right spinal gutter.

since in the group studied symptoms and signs only occurred in those individuals in whom there was other lung pathology. Apparently the plaques themselves and the process responsible for producing them are symptomless.

DISCUSSION

Fibrosis. The type of fibrosis found in this study was characterized, as already described, by a soft haziness and a *finely* granular or nodular appearance tending to be more marked in the mid-lung fields and bases. Dreessen[3] apparently found a condition somewhat similar to this in his study of tremolite talc workers in the same geographical area. However, the fibrosis here reported was more severe than that found by Dreessen as indicated by the conspicuous presence of clinical symptoms, such as dyspnea, pain and fatigue in these cases and also by the more frequent appearance of granulation and fine nodulation. It more closely resembled in severity the fibrosis later reported by Dreessen and Dalla-Valle[4] among Georgia talc millers and miners. Here the talc was also of the tremolite variety. Analyses also failed to show the presence of free silica. These authors reported 8 cases with symptoms of dyspnea, cough and pain, abnormal chest signs,

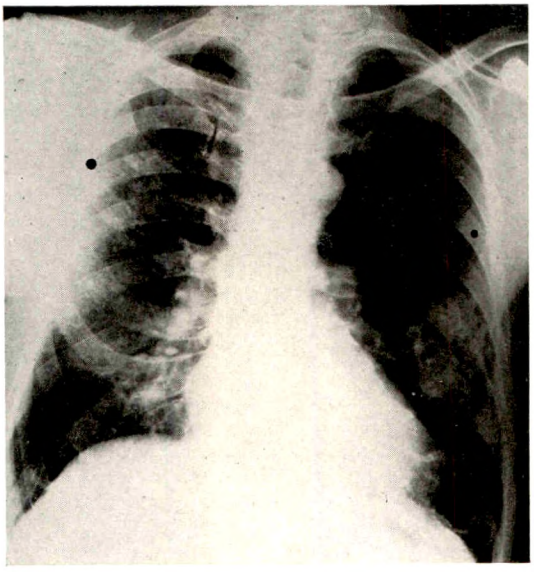


Fig. 14. Case 196-16. Aged fifty-two. Began working at age of fifteen. Farmer twelve years; worked on railroad four years; talc mill worker thirty-one years. No complaints. *Physical examination:* Chest expansion 1¾ inches, breath sounds distant. Nails Curved. *Roentgen examination:* Shows what appears to be an extensive, irregular, sharply defined deposit of opaque material in the left lung field. Stereoscopic view shows that this deposit is at the periphery, probably on the visceral pleura, and that the lung beneath is comparatively free from fibrosis. The right lung shows a fine, diffuse, granular fibrosis with shadows in the first and second interspaces suggesting healed reinfection tuberculosis.

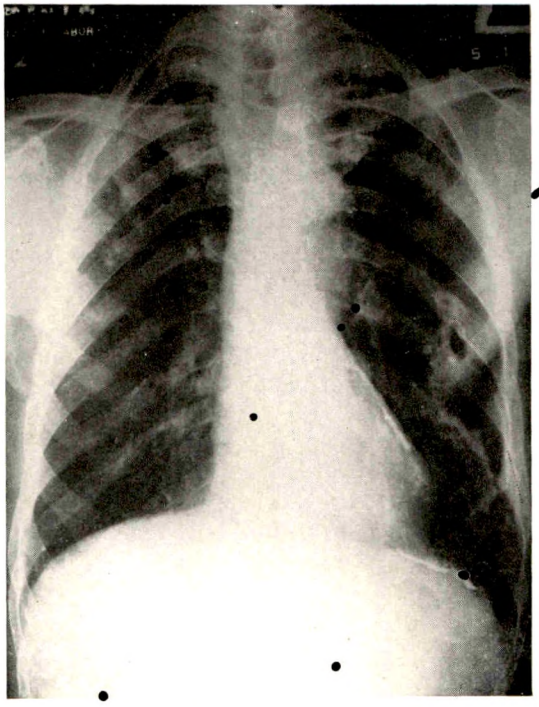


Fig. 15. Case 199-16. Aged sixty-three. Began working at age of sixteen. Talc mill laborer sixteen years; talc miner thirty-one years. Complains of productive cough, night sweats, pain in chest, loss of weight and appetite. *Physical examination:* Chest flat, expansion 1¾ inches, lungs dull both apices, diminished breath sounds, nails curved. *Roentgen examination:* Shows what appears to be deposits of opaque material on the left diaphragm and pericardium; also an extensive irregular deposit on the left pleura. Stereoscopic view indicates that the latter is on the visceral pleura. Soft shadows indicative of moderately advanced tuberculosis are present in both apices, extending to the third interspace on the right and the second on the left.

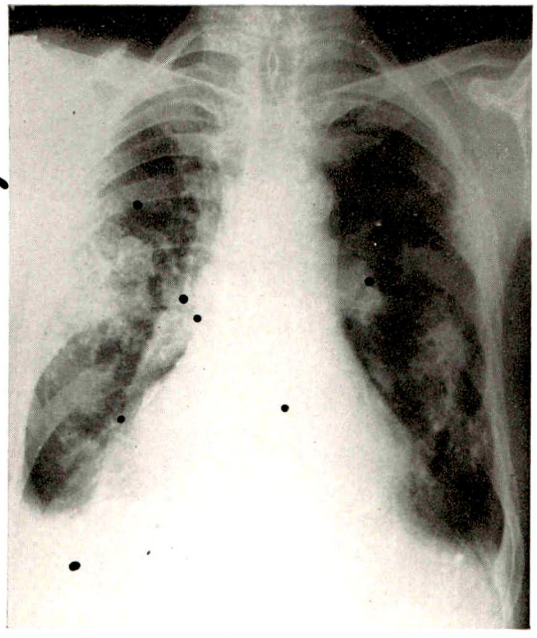


FIG. 16. Case 198-40. Aged sixty-four. Began working at age of sixteen. Paper mill five years; carpenter six years; zinc miner three years; talc miner and blacksmith twenty-one years; talc mills thirteen years. Complains of productive cough, shortness of breath, fatigue, and night sweats. *Physical examination:* Chest expansion 1¼ inches. Respiratory rate 32; pulse 112. The lungs are hyperresonant. There are bronchovesicular breath sounds with râles throughout right lung. Curved nails. *Roentgen examination:* Shows extensive areas of increased density which suggest irregularly shaped deposits of opaque material in both lung fields. This appears to be not exactly at the periphery but several millimeters inside the lung field. There is also a rather dense accumulation of opaque material on the right and left leaves of the diaphragm, along the right pericardial border and arch of the aorta. The right costophrenic sulcus is obliterated. The lung tissue, apart from the areas described, shows an increase in lung markings more marked on the right.

clubbed fingers, and a nodular or "nodular-conglomerate" type of fibrosis.

The occurrence of a type of fibrosis giving a nodular roentgen appearance as a result of exposure to tremolite talc dust is a matter of considerable interest, since nodular fibrosis is traditionally associated only with dust containing free silica. Gardner[8] attributes fibrosis in tremolite talc workers to the contaminating presence of free silica, but inasmuch as the free silica content of the twelve samples of mineral from talc mills and mines analyzed in the present study was found to be practically negligible (less than 1 per cent), it seems reasonable to suppose that the fibrosis observed in these cases is primarily the result of the inhalation of the various silicate minerals present in the dust, namely talc, tremolite and anthophyllite.

Microscopic study has shown that this dust is largely fibrous in character, and it may well be that this particular physical characteristic is responsible for the pathology of tremolite talc fibrosis. The possibility of action analogous to that which occurs in asbestosis is suggested by several facts: first, the chemical and physical similarity between the minerals in this area and those found in asbestos; second, the fact that the disability in tremolite talc fibrosis, like that in asbestosis, tends to be greater than one would expect from the severity of the lesion as seen on roentgenological examination.

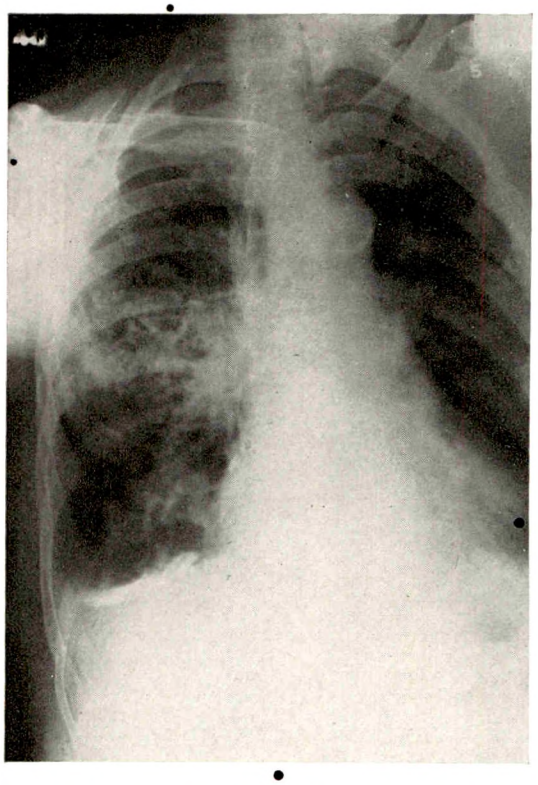


FIG. 17. Same case as Figure 16. Oblique view.

Because of these similarities, the authors of this paper have taken the opportunity to compare this series of films of tremolite talc workers with those of a group of workers showing early asbestosis.* They were impressed by the resemblances in the roentgen appearances in the two groups. The talc fibrosis resembled early asbestosis in its fineness and diffuseness, its hazy "ground glass" quality and, in addition, some in the series of asbestosis films showed a mottled or nodular appearance similar to that seen in the more advanced cases of talc fibrosis.†

Whatever the exact pathology may ultimately prove to be, the study here reported clearly indicates, from a practical standpoint, that the dust encountered in the tremolite talc industry is of a definitely injurious, fibrosis-producing type which requires control in order to prevent disabling occupational disease. Moreover, although the number of cases here presented is small, suggestive evidence has been found that exposure to tremolite talc dust is associated with increased susceptibility to tuberculosis.

Talc Plaques. In regard to "talc plaques," one possibility to consider is that they represent simply aggregations of actual talc dust which has remained in the periphery of the lung unable to be disposed of in any manner. This supposition makes it difficult, however, to account for the presence of these deposits in a few cases only, rather than in the majority of those exposed.

Since "talc plaques" closely resemble, in appearance, pleural calcifications resulting from traumatic pleuritis or empyema, the thought immediately suggests itself that they are, in fact, deposits of calcium. The dust of tremolite talc contains calcium—tremolite being a calcium magnesium silicate—but so also do other dusts such as cement and marble. Why does tremolite talc dust alone produce the opaque deposits described?

Calcific deposits ordinarily presuppose previous irritation or injury. This fact suggests that tremolite talc dust, therefore, has some unique ability to irritate or injure pleural surfaces, such injury being followed by the deposition of readily available calcium. It is known, for example, that the resolution of intrapleural hemorrhage is frequently followed by calcium deposition, and one is tempted to speculate as to whether the needle-like particles present in this dust may, by tissue penetration, cause multiple, minute, capillary hemorrhages whose resolution results in the appearances described.

The location of the deposits, as seen in lateral, oblique and stereoscopic views, appears actually to be just beneath the pleural surface. This suggests that they may lie in the peripheral lymphatic network and opens up another speculative possibility. In this connection an illustrated article by Lommel[14] in *Deutsche medizinische Wochenschrift* is of great interest. Discussing the familiar "egg shell" appearance occasionally seen in hilar nodes, he reports, in certain cases of silicosis, large calcific deposits in the peripheral parts of the lung which, to judge by the illustrations, closely resemble "talc plaques." His suggested explanation is that calcium (lime) is laid down in inflamed fibrous tissue in the congested lymph spaces which form a network around the lobules of the lung.

The sharply demarcated, yet irregular, borders of the "talc plaques" do in fact suggest that the deposit of opaque material is definitely limited as by the outlines of some irregularly shaped structure such as the walls of lymphatic spaces. It is of interest in this connection that Gardner and Cummings,[9] working with asbestos, report well marked hyperplasia and dilatation of lymphoid tissue in the periphery of the lung in guinea pigs which they believe may be the result of pulmonary irritation. One may speculate as to whether tremolite talc may not produce a similar condition which is then followed by the deposition of calcium already present in the dust.

* Through the courtesy of Dr. W. J. McConnell of the Metropolitan Life Insturance Co., New York City.

† "Mottling" in asbestosis has been described by Merewether[1] and also by Gardner and Cummings.[9]

Another interesting feature of the cases showing talc plaques is that radiopaque material in these cases is not, apparently, deposited in the hilar nodes. This suggests that talc dust does not find its way to them in large amounts. If this be true, it would indicate a similarity in this respect to asbestos which, as Gardner and Cummings have shown, tends to be held in the periphery of the lungs.

Whatever the similarity in effect between asbestos and talc dust, however, one conspicuous dissimilarity is the absence of any change resembling "talc plaques" in the lungs of asbestos workers. In fact, as far as we are aware, with the single exception of the German reference[14] given above, such deposits have not heretofore been described in connection with any dust.

SUMMARY

1. A study of the tremolite talc mining and milling industry in northern New York State is reported.

2. Talc in this region is of the asbestine variety, mingled with tremolite and anthophyllite. Analyses of material from both mines and mills gave consistently a free silica content of 1 per cent or less. Microscopic studies of dust showed the presence of fine, straight, needle-like fibers.

3. Dust counts in mining ranged from 6 to 5,000 million particles per cubic foot; in milling from 20 to 215 million perticles per cubic foot.

4. In a group of 221 tremolite talc miners and millers advanced fibrosis was found in 32 men, giving an incidence of 14.5 per cent.

5. All of the cases of fibrosis occurred among those men who had worked in tremolite talc for ten years or longer (107 men), giving an incidence for this group of 29.9 per cent.

6. The fibrosis found in this study was of a fine, diffuse type with a roentgenographic appearance of granulation or nodulation on a hazy background. It tended to be disabling in character and was frequently accompanied by dyspnea, cough and fatigue.

7. There was also some evidence that this fibrosis was characterized by an increased susceptibility to tuberculosis. Clinically significant tuberculosis was diagnosed by roentgen examination in 3 of 18 cases of tremolite talc fibrosis where there had been no other dust exposure.

8. In addition to fibrosis, deposits of unidentified opaque material in the periphery of the lungs, including the region of the diaphragm and pericardium, designated as "talc plaques," were observed in 6.3 per cent of all tremolite talc workers examined. These deposits occurred independently of other lung pathology and could not be identified with any particular signs or symptoms.

CONCLUSIONS

This study identified tremolite talc as a silicate dust capable, like asbestos, of causing a disabling pneumoconiosis. It reveals distinctive pathological findings associated with exposure to tremolite talc dust which postulate a special etiology for the resulting disease. There is also evidence that tremolite talc fibrosis is associated with an increased susceptibility to tuberculosis.

In the light of these findings, exposure to tremolite talc dust must be considered to constitute a definite industrial hazard requiring control of dust by suitable engineering methods.*

REFERENCES

1. Annual Report Chief Inspector of Factories and Workshops for England and Wales. His Majesty's Stat. Off., London, 1933, p. 63 (Merewether); 1934, p. 65 (Merewether).
2. BETHUNE, N. Pleural poudrage; new technic for deliberate production of pleural adhesions as preliminary to lobectomy. *J. Thoracic Surg.*, 1935, *4*, 251–261.

* Since this paper was written, an article on experimental production of intrapleural adhesions in animals by Hanrahan, Adams and Klopstock has appeared in the Fifty-Seventh Annual Medical Report of the Trudeau Sanatorium. In the case of one rabbit treated with iodized talc, the authors report, "The medial half of the diaphragm contained a subpleural collection of powder, 0.5 mm. in thickness, lying in situ as a semirigid plaque. . . . Mediastinal and diaphragmatic distribution suggested complete lymphatic blockage."

3. Dreessen, W. C. Effects of certain silicate dusts on the lung. *J. Indust. Hyg.*, 1933, *15*, 66–78.
4. Dreessen, W. C., and DallaValle, J. M. Effects of exposure to dust in two Georgia talc mills and mines. *Pub. Health Rep.*, 1935, *50*, 131–143.
5. Fienberg, R. Talcum powder granuloma. *Arch. Path.*, 1937, *24*, 36–42.
6. Fossel, M. Ueber die Wirkung des Talkumstaubes im Tierexperiment. *Frankfurt. Ztschr. f. Path.*, 1935, *49*, 90–95.
7. Fourth Saranac Laboratory Symposium on Silicosis, June 19 to 23, 1939.
8. Gardner, L. U. Personal communication, 1942.
9. Gardner, L. U., and Cummings, D. E. Studies on experimental pneumonokoniosis. IV. Inhalation of asbestos dust; its effect upon primary tuberculous infection. *J. Indust. Hyg.*, 1931, *13*, 65–81; 97–114.
10. Haynes, F. Experimental dust inhalation in guinea-pigs. *J. Hyg.*, 1931, *31*, 96–123.
11. Industrial Bulletin, New York State Department of Labor, 1938, 17, 1.
12. International Labor Office. Silicosis. Proc. Internat. Conference held in Geneva, from August 29 to September 9, 1938.
13. Ladoo, R. B. Non-metallic Minerals. McGraw-Hill Book Co., Inc., New York, 1925.
14. Lommel, F. Ueber Beurteilung und Verhütung der Silikose (Staublungenkrankheit). *Deutsche med. Wchnschr.*, 1939, *65*, 871–875.
15. McCormick, E. J., and Ramsey, T. L. Postoperative peritoneal granulomatous inflammation caused by magnesium silicate. *J. Am. M. Ass.*, 1941, *116*, 817–821.
16. Middleton, E. L. Industrial pulmonary disease due to inhalation of dust, with special reference to silicosis. *Lancet*, 1936, *2*, 1–9; 59–64.
17. Miller, J. W., and Sayers, R. R. Physiological response of peritoneal tissue to certain industrial and pure mineral dusts. *Pub. Health Rep.*, 1936, *51*, 1677–1689.
18. Mineral Resources of the State of New York. New York State Museum Bulletins No. 223, 224. Albany, New York.
19. Nuck, K., and Szczepanski, W. Talk and Talkstaublunge. Arbeitsmedicin, Vol. 9. J. A. Barth, Leipzig, 1939.
20. Policard, A. Action des poussières de talc sur les poumons. *Arch. d. mal profess.*, 1940, *2*, 530–539.
21. Schulz, R. Z., and Williams, C. R. Commercial talc; animal and mineralogical studies. *J. Indust. Hyg. & Toxicol.*, 1942, *24*, 75–79.
22. Stüber, K. Cellular response of lymph nodes to various dust suspensions introduced into lymphatics. *J. Indust. Hyg.*, 1934, *16*, 282–295.
23. Zanelli, A. La pneumoconiosi da talco. *Med. del lavoro*, 1931, *22*, 3–16. Quoted by Teleky, L. Pneumoconiosis. Supplement Occupation and Health. International Labor Office, Geneva, 1938.

UNIVERSITY COLLEGE OF MEDICINE
LIBRARY
U. U.

VIRUS PNEUMONIA

ROENTGENOGRAPHIC CHARACTERIZATION OF RECENT VIRUS PNEUMONITIS WITH BRONCHOPNEUMONIA

By ASA E. SEEDS, M.D., *and* MORTON L. MAZER, M.D.
Department of Radiology, Baylor University College of Medicine
DALLAS, TEXAS

THE paucity of autopsy material available for the study of virus pneumonitis is an academic handicap, but enough of a humane blessing to allay regret; these circumstances place an emphasized burden of responsibility on bacteriologic consultants and deductive forms of clinical analysis. Not the least of the latter is, we believe, accurate roentgenographic observation and deductive correlation of findings.

The characteristic roentgenographic appearance, the characteristic distribution, and the fairly characteristic changes in evidence of development and recession—resolution—of lobar (pneumococcus) pneumonia are uniform, dependable and well known. Since this disease entity provides, such a regular syndrome of history, symptoms, physical signs, bacteriologic findings and short routine typical course, roentgenographic examinations have come to fill an order of somewhat secondary importance in lobar pneumonia. Roentgenologic consultation is important largely for the following:[18]

A. A study of correlative findings in early stages of a relatively typical syndrome.
   1. Verification of physical findings, rarely necessary in frank cases.
   2. Localization of process; more important on the right side of the chest.
   3. Record of conditions as a clinical course-record "base line".
   4. Identification or exclusion of any coexistent complication.

B. Study of special phases of early stages of not-so-typical syndrome.
   1. Identification of process, in case of vague history and physical signs.
   2. Especially in the face of symptoms and/or signs outside of the thorax: in the abdomen, meninges or central nervous system.
   3. Or identification of late phase of previously unrecognized pneumonic process resulting from mild pneumococcic pathogen.

C. Differentiation of a case at hand from a multitude of other intrathoracic diseases when the history, physical findings, or course seem unreliable.

D. Serial studies in case of complication both immediate and presistent such as empyema, delayed resolution, chronic fibrosing non-resolution, and/or subsequent bronchiectasis, acquired type.

The group designated under C above would likely include the disease entity, as we choose to call it, which forms the nucleus of interest in this presentation.

LITERATURE

As early as 1932 and 1933 French[3] and German[22] authors were describing a typical pneumonic process with atypical distribution, usually not involving even a large part of a single lobe, apparently not always accompanied by pneumococcus infection. "These cases," if they may be successfully grouped, were soon (1935) referred to as pneumonitis in the American[4] literature and a discussion of the definition of this term and syndrome ensued. Some of the roentgenographic findings were quite simply typical of lobular (segmental) consolidation and others were consistent with what we now feel can be identified as true virus pneumonitis and bronchopneumonia: a combination of a simple infiltrative processes and minor, even minute, areas of consolidation and partial consolidation. The latter component of this duel process

was frequently subsequent to the former factor and possibly equally dependent on it *and* a secondary invading organism.

As one analyzes more recent reports, the number of infiltrative (pneumonitic) examples has steadily increased until they predominate in the reports of Reimann[14] and constitute a relatively pure subject of discussion for a paper by Smiley, Showacre, Lee and Ferris.[19]

The clinical syndrome has been growing even more uniform both here and in the descriptions of others since 1937 and has been briefly as follows:[8,19]

1. An insidious febrile onset. Progressive regular rise and fall of body temperature without diurnal regularity reaching 103–105° F. after the first day or two.
2. Accompanied by progressive malaise and often severe headache and occasionally severe chest pain.
3. Third or fourth day development of a cough, usually unproductive.
4. Commonly no significant or localized physical finding up to this time and frequently even for some days.
5. Low leukocyte count and negative sputum. A filtrable virus in same groups apparently characterizable by certain animal inoculations which can be duplicated and continued.
6. Early minor, usually centrally located, roentgenographic findings in examination of the lungs by the third to the fifth day.
7. Slowly developing "crescendo" type clinical course: ten to twelve days total elapse of time; followed by decrudescence by lysis, but mild rise in leukocyte count and some productive cough but nonspecific sputum.
8. Or migration of signs, recrudescence of severity and beginning important rise in leukocyte count; probably representing more serious secondary invader.
9. This last mentioned phase is the only one in which sulfonamide drugs appear to be indisputably effective.
10. This process has a definite trend toward contagion as evidenced by familial and other gregarious grouping.

In the past year we have seen 279 reasonably certain cases of primary pneumonia in 221 of which (74 per cent) the history, findings and course have followed the above outline and pattern with remarkable uniformity. The remaining 58 cases encompassed a relatively large group of variable types of primary pneumonic processes. Typical lobar pneumonia with pneumococcus identification has been predominant (42 cases).

Of 254 sputum examinations for pneumococcus identification and typing performed here in the past year, 172 have been negative and some 25 to 35 were positive for types of questionable pathogenicity. This trend seems quite parallel in potentialities to our independent classification of the roentgenologic findings.

DESCRIPTIVE DISCUSSION

Of more interest to us as roentgenologists have been the roentgenographic characteristics of the 221 cases of atypical, possibly virus, pneumonia.

We have come to feel that there are several characteristics of the roentgenographic evidence of this syndrome other than inconstant peculiarities in distribution. In fact, a few of these characteristics seem to be almost exclusive. We, of course, realize that they cannot be considered pathognomonic, since, so far as we know, they do not represent specifically one pathologic process; since, as a matter of fact, we have practically no pathologic material for study. Though the roentgenographic peculiarities of this syndrome do follow the non-lobular, non-segmental and inconstant distribution pattern previously described by many authors, we feel that this distribution pattern is followed in a more or less orderly manner both as to location and as to the progressive chronological development, even of the various "units" in the cases in which they are multiple. We also

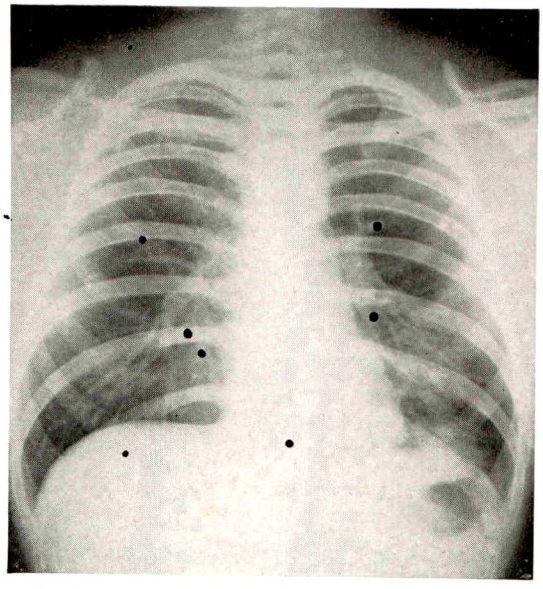


FIG. 1. "Cotton-wool" appearance of centrally located early infiltration and partial consolidation.

feel that a descriptive structural analysis of these processes is characteristic with surprising constancy.

We should like to present our idea of these findings in the following form and offer some pertinent examples as well as examples of some contrasting lesions for standardization (see illustrations). We have found these examples a reasonably constant rule rather than an exception.

1. An infiltrative process at the onset.
   A. First progressively peribronchial from the hilum and then irregularly interbronchial; earlier in the more proximal portion.
   B. Customarily clearly definable as to limits in spite of its disregard for segmental or lobar structural limits, usually involving more than one segment and frequently parts of more than one lobe.

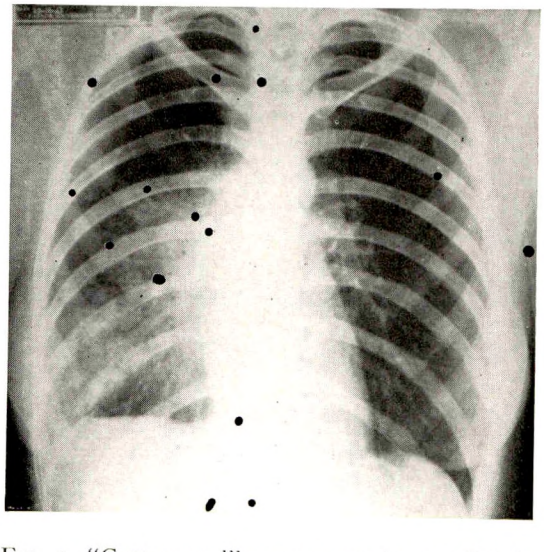


FIG. 2. "Cotton-wool" appearance in so-called inverse phase or resolution with new area or unit developing from right upper hilum.

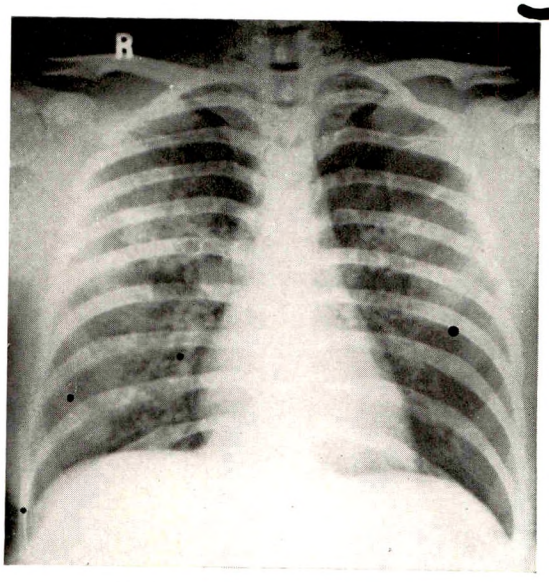
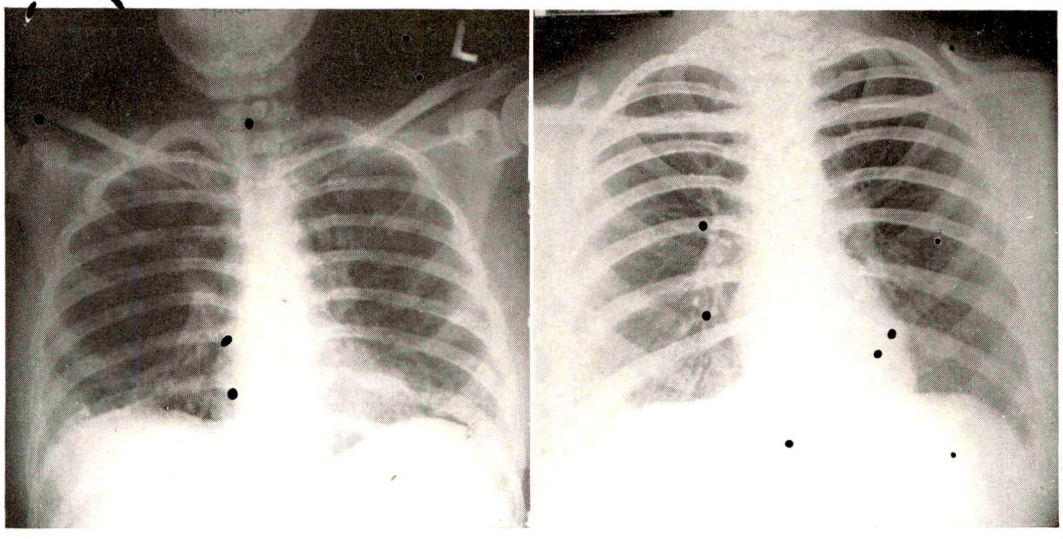


FIG. 3. Early "wire-grass" type infiltration characterizing mid-resolution.

2. Quickly accompanied by a "cotton-wool" appearance of multiple areas of partial or semi-consolidation.
   A. This is scattered through the area of infiltration; usually distributed in a radial progression also.
   B. Frequently subsequently (six to twenty-four hours) coalescing.
   C. Occasionally eventually (twenty-four to forty-eight hours) filling approximately a whole lobe to simulate lobar pneumonia but, so far as we have seen, always managing to present a striated infiltra-



A *B*

FIG. 4. *A*, late "wire-grass" type infiltration (pseudofibrosis). *B*, same case showing the lungs entirely clear in one week.

tive type background rather than a pure homogenicity.

D. Usually establishing a fixed distribution for any one area in two to three days, which afterward behaves as a "unit."

3. Resolution or absorption begins.

A. By generalized and uniform progressive (three to five days) loss of density throughout the "unit."

B. The development of an appearance of "wire-grass" infiltration or

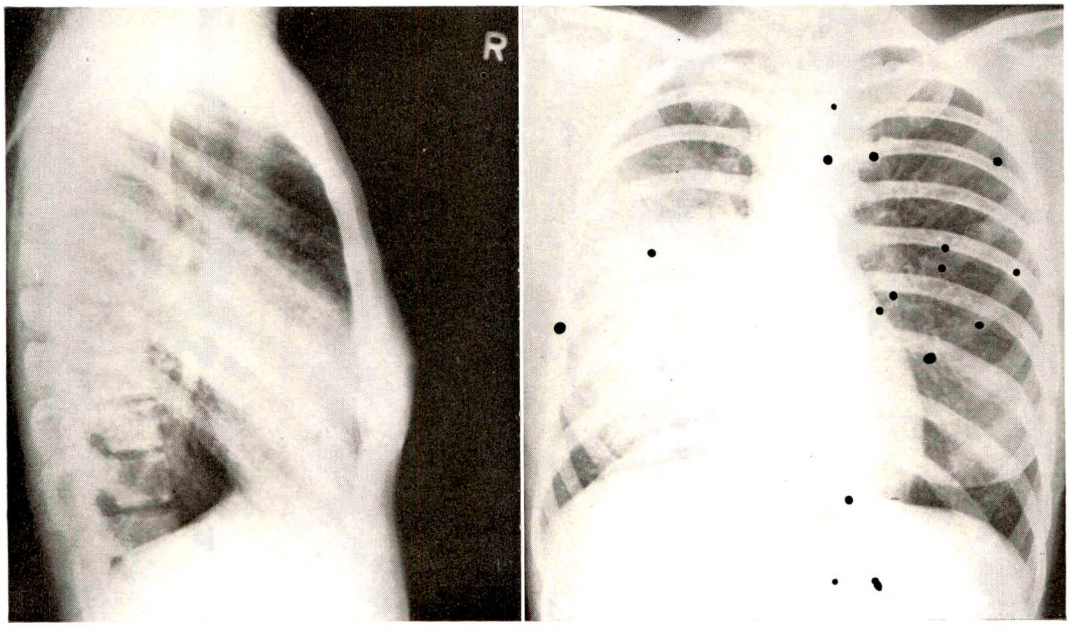


FIG. 5. Extensive distribution simulating lobar pneumonia. Actually the extension is beyond lobar lines and a striated characteristic, mentioned in the text, is retained.

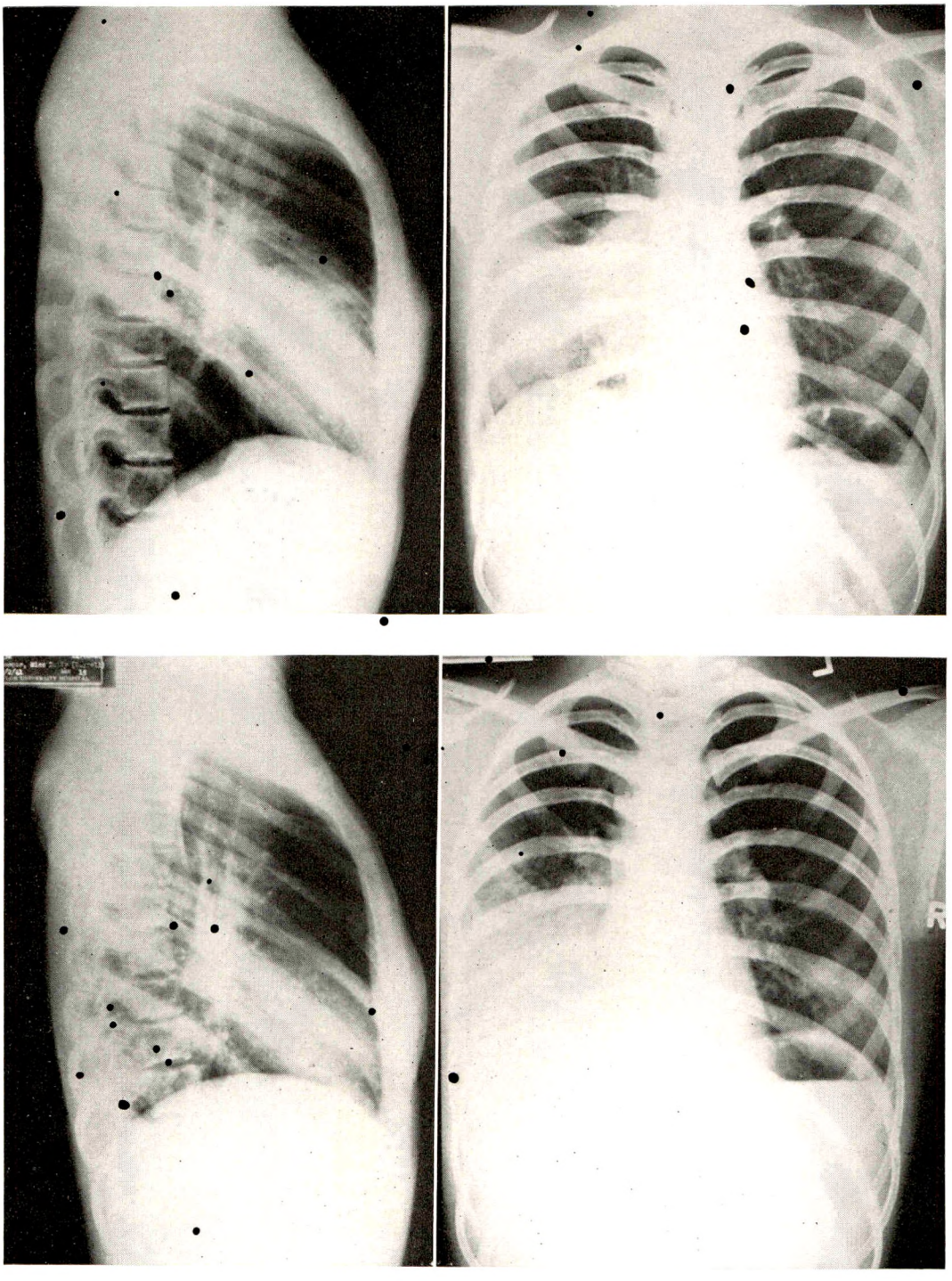


FIG. 6. Two examinations of same patient within forty-eight hours showing (top to bottom) distribution simulating lobar pneumonia but developing lesion characteristics rapidly, indicating a non-pneumococcus process.

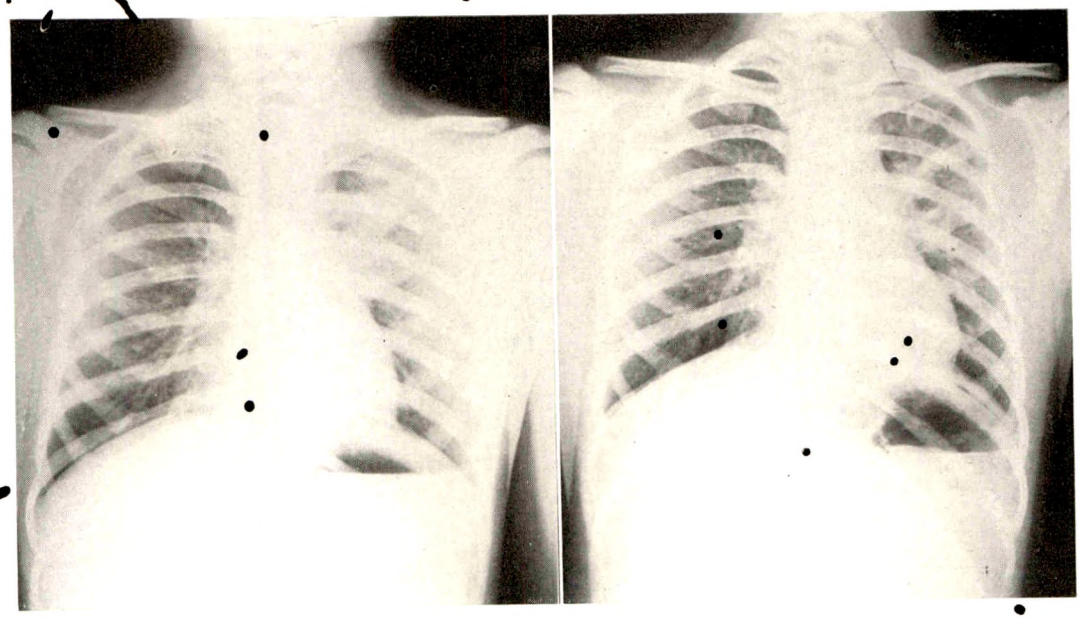


FIG. 7. Typical process and seventy-two hour sequence in seven year old child.

"pseudofibrosis" (suggesting a relatively simple inverse of the developing process).

C. Eventual progressive complete clearing of this process in five to fourteen days, usually five to eight days in cases of single "units."

4. Occasional development of multiple "units" with
   A. Subsequent definite dates of onset and individual chronology.
   B. Rarely, involving nearly all visible parts of lung.
   C. Usually no one unit disturbing the approximate prearranged chronology of any forestarted unit.
5. Occurring quite typically in children.
   A. We recorded only one typical case under six months, but many both under and over two years.

COMMENT

Due to evident difficulty in clinical diagnosis produced by such incipient changes as those which characterize the early onset of this syndrome, we submit that roentgenographic diagnostic procedures have acquired a position of primary importance here. This position, at least for the moment, is in contrast with the recent secondary position of roentgenology in classical lobar pneumonia due to pneumococcus. Naturally, we do not hold with any idea that this syndrome should be expected to maintain a permanent dominant position in the problem of pneumonic processes. Nor do we expect that this degree of uniformity will

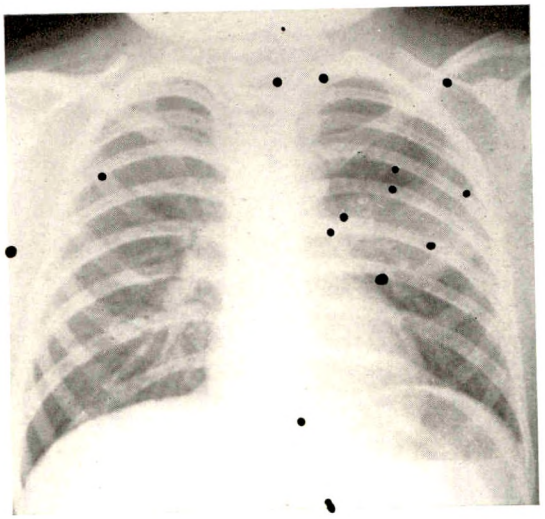


FIG. 8. Typical location, uniform density and definition of lobular pneumococcus pneumonia in a child.

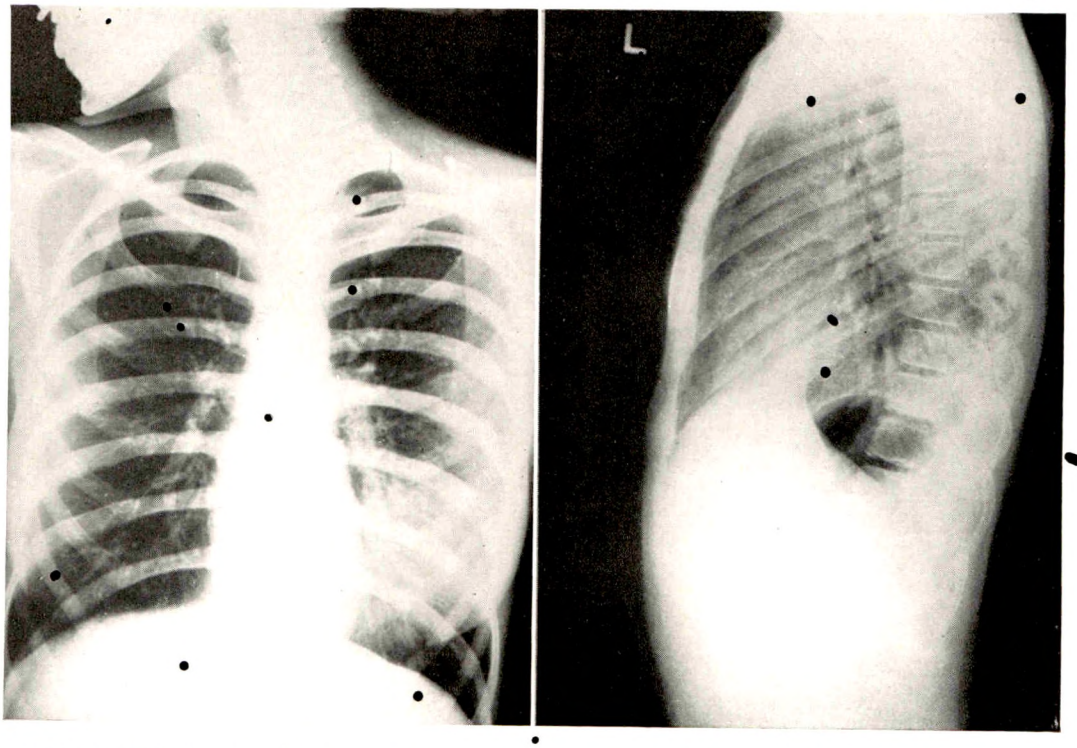


FIG. 9. Typical middle stage (five days after onset) process with typical distribution differing from lobular pneumonia in similar location having similar distribution but different appearance.

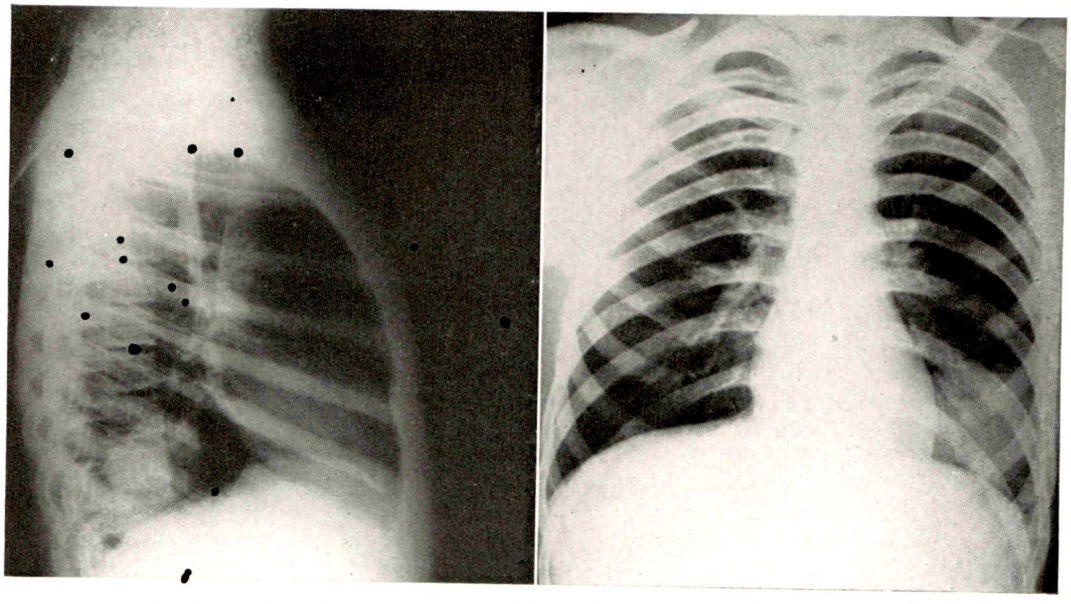


FIG. 10. Characteristic localized segmental or lobular pneumococcus pneumonia of location and size similar to Figure 9.

enjoy widespread geographic distribution. The secondary variants of pneumonia from the pneumococcus have been inconstant in different time cycles and at the same time varied further in separated localities in the same season. We do feel that it represents a currently important cyclic variant of acute pulmonary diseases and is perhaps in the midst of the crescendo of its own importance this year. Nevertheless, it has been gratifying to us to be able to develop some criteria of roentgenographic recognition of this syndrome during the time that it has been so prevalent, and here in the Southwest where it has developed such an apparently pure form. It has been gratifying to find considerable reassurance in the reasonable correlation of findings with other departments. It is paradoxically ungratifying from an academic standpoint to be afforded almost no material for objective verification.

We shall have to rely upon the field of bacteriology to provide eventually a practical and quick means of identifying and subclassifying filtrable virus.

CONCLUSIONS

1. A group of 221 cases of non-lobar (non-pneumococcus) pneumonia have been related and discussed as to certain features. The clinical and laboratory findings correlate well with previously described groups of febrile episodes apparently due at least in part to infection with a filterable virus; possibly one peculiar to this syndrome.

2. We believe that we are able to demonstrate certain pulmonary roentgenologic characteristics of this syndrome over and above "distribution unusual to lobar pneumonia," and inconstancy within its own group.

3. We believe that a remarkably large proportion of these cases follow a fairly constant roentgenologic course, in either single, double, or occasionally multiple chronological "units" or episodes.

4. Staggered concurrence is typical in cases of multiple units.

5. The roentgenologic identification of this entity is important in the face of the common difficulty of establishing dependable clinical identification in typical cases.

REFERENCES

1. Adams, J. M. Primary virus pneumonitis with cytoclasmic inclusion bodies. *J. Am. M. Ass.*, 1941, *116*, 925–933.
2. Allen, W. H. Acute pneumonitis. *Ann. Int. Med.*, 1936, *10*, 441–446.
3. Bezançon, F., Jacquelin, A., Lehman, R.D., and Tribout. Contribution à l'étude radiologique des pneumopathies aiguës. *Presse méd.*, 1933, *41*, 1867–1871.
4. Bowen, A. Acute influenza pneumonitis. Am. J. Roentgenol. & Rad. Therapy, 1935, *34*, 168–174.
5. Gill, A. M. Pneumonitis. *Brit. M. J.*, 1938, *1*, 504–507.
6. Goodpasture, E. W., Auerbach, S. H., Swanson, H. S., and Cotter, E. F. Virus pneumonia of infants secondary to epidemic infections. *Am. J. Dis. Child.*, 1939, *57*, 997–1011.
7. Horsfall, F. L., Jr., and Lennette, E. H. Synergism of human influenza and canine distemper viruses in ferrets. *J. Exper. Med.*, 1940, *72*, 247–259.
8. Kneeland, Y., Jr., and Swetana, H. F. Current bronchopneumonia of unusual character and undetermined etiology. *Bull. Johns Hopkins Hosp.*, 1940, *67*, 229–267.
9. Lennette, E. H., and Horsfall, F. L., Jr. Studies on influenza virus; complement-fixing antigen of influenza A and swine influenza viruses. *J. Exper. Med.*, 1941, *73*, 581–599.
10. Magill, T. P. Virus from cases of influenza-like upper-respiratory infection. *Proc. Soc. Exper. Biol. & Med.*, 1940, *45*, 162–164.
11. Maxfield, J. R., Jr. Atypical pneumonia with leukopenia. *Texas State J. Med.*, 1939, *35*, 340–346.
12. Miller, F. N., and Hayes, M. G. Bronchopneumonia of mild severity at University of Oregon. *Northwest Med.*, 1939, *38*, 12–14.
13. Ramsay, H., and Scadding, J. G. Benign broncho-pulmonary inflammations associated with transient radiographic shadows. *Quart. J. Med.*, 1939, *8*, 79–95.
14. Reimann, H. A. Acute infection of respiratory tract with atypical pneumonia; disease entity probably caused by filtrable virus. *J. Am. M. Ass.*, 1938, *111*, 2377–2384.
15. Reimann, H. A., and Stokes, J., Jr. Epidemic infection of respiratory tract in 1938–1939; newly recognized entity. *Tr. Ass. Am. Physicians*, 1939, *54*, 123–129.

16. REIMANN, H. A. Pneumococcal and "virus" pneumonia. *Bull. New York Acad. Med.*, 1941, *17*, 187–194.

17. SAYÉ, L. Diagnostico diferencial de las bronconeumopatías agudas tuberculosas y no tuberculosas. *Rev. méd. de Barcelona*, 1935, *24*, 365–401.

18. SEEDS, A. E. Value of roentgen diagnosis in pneumonia. Presented before Dallas County Medical Society, February, 1941. To be published.

19. SMILEY, D. F., SHOWACRE, E. C., LEE, W. F., and FERRIS, H. W. Acute interstitial pneumonitis; new disease entity. *J. Am. M. Ass.*, 1939, *112*, 1901–1904.

20. STOKES, J., JR., KENNEY, A. S., and SHAW, D. R. New filterable agent associated with respiratory infections. *Tr. & Stud., Coll. Physicians, Philadelphia*, 1939, *6*, 329–333.

21. STUART-HARRIS, C. H., SMITH, W., and ANDREWES, C. H. Influenza epidemic of January–March, 1939. *Lancet*, 1940, *1*, 205–211.

22. TESCHENDORF, H. J. Ueber besondere Erscheinungsformen der Grippepneumonie im Röntgenbild. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1933, *48*, 541–547.

23. WEIR, J. M., and HORSFALL, F. L., JR. Recovery from patients with acute pneumonitis of a virus causing pneumonia in the mongoose. *J. Exper. Med.*, 1940, *72*, 595–610.

Vol. 49 No. 1

DUODENAL ULCER SYNDROME CAUSED BY ANKYLOSTOMIASIS

REPORT OF TWENTY-FIVE CASES WITH GASTRIC ACIDITY AND ROENTGENOLOGICAL STUDIES*

By H. A. YENIKOMSHIAN, M.D., D.T.M.&H., M.R.C.P., *and* WILLIAM H. SHEHADI, M.D.†

From the Departments of Medicine and Roentgenology, School of Medicine, The American University
BEIRUT, LEBANON, SYRIA

GASTROINTESTINAL disturbances caused by hookworm disease may appear in different clinical forms, including that of duodenal ulcer. The symptoms are often vague and indefinite, the patients complaining of heartburn, flatulence, a feeling of fullness of the abdomen and irregular bowel movements. In some cases patients complain of epigastric pain, more marked two to four hours after meals, increased by pressure, but relieved by food and/or alkalis. In localities where ankylostomiasis is very common, dyspepsia associated with severe anemia suggests the diagnosis of hookworm disease. On the other hand, in those countries where hookworm disease is rare, or the infection is light, ankylostomiasis as a cause of painful dyspepsia is often ignored and not considered in differential diagnosis. In those cases where hookworm disease causes symptoms suggestive of duodenal ulcer, a definite diagnosis can be made only by finding ova of *Ankylostoma* in the stools and by roentgenological examination of the gastrointestinal tract with the barium meal.

Ankylostomiasis in Lebanon and Syria, as in many other parts of the world, does not constitute a major public health problem and may be considered of more or less negligible economic and medical importance.[18,25] However, more and more cases are being recognized and its significance from the standpoint of differential diagnosis and treatment is becoming increasingly appreciated.

In the Out-patient Clinics and Hospitals of the American University of Beirut, we have had patients whose clinical history was very suggestive of chronic duodenal ulcer, but in whom stool examination revealed presence of ova of *Ankylostoma duodenale*. These patients have had complete relief from their digestive symptoms soon after the hookworm infestation was cleared. We have noted that some of these patients in whom hookworm disease was associated with painful dyspepsia suggestive of duodenal ulcer gave no history of recent hematemesis or malaria, had severe anemia, microcytic in type. It is a well known fact that painful dyspepsia due to duodenal ulcer is usually associated with high gastric acidity, while hypochlorhydria or achlorhydria is the common finding in anemias. This unexpected association of peptic ulcer syndrome with severe anemia due to hookworm disease prompted us to investigate the gastric acidity and to make roentgenological studies of the gastrointestinal tract of patients with ankylostomiasis. Since etiological relation of gastric acidity to duodenal ulcer and the relation of certain types of anemias to diseases of the gastrointestinal tract is being widely studied at the present time, our observations seemed to us of sufficient interest to be presented in this communication.

Hookworm disease in Syria and Lebanon is confined to certain areas along the coast and to inland districts along the banks of the Euphrates and Orontes Rivers.[3,12,18,25] It is prevalent among gardeners most of whom are poor and uneducated and to

* Read at the Twelfth Medical Conference of the Medical Alumni Association of the American University of Beirut, April 28, 1939.
† Now Assistant Professor of Radiology, College of Medicine, University of Vermont, Burlington, Vermont.

TABLE I

Case No.	Sex and Age	Chief Complaint and Duration	Free Gastric Acidity	Red Blood Cell Count	Hemoglobin	Roentgen Findings	Complications	Remarks
1	M 25	Epigastric pain ½–2 hr. p.c. Relieved by alkalis not by food; 1 mo. duration	25	3,700,000	70%	Spastic cap, tenderness, exaggerated and reversed peristalsis in duodenum	Blood Wassermann 4 plus; diarrhea	Pain relieved second day after vermifuge. Roentgen examination normal after 17 days
2	M 35	Epigastric pain relieved by food, 2 yr. duration. Dyspnea on exertion	45	2,230,000	30%	Pylorospasm, irritability of descending duodenum. Occasional reversed peristalsis	—	Complete relief of pain on second day after vermifuge. Roentgen recheck 6 mo. later, normal
3	M 41	Epigastric pain 2–3 hr. p.c. relieved by food and alkalis; 6 mo. duration	42	3,700,000	70%	Pylorospasm, tender and irritable duodenal cap. Swelling of mucosa of proximal jejunum	—	Complete relief on second day after vermifuge. Roentgen findings unchanged after 3 days
4	M 21	Epigastric pain 2–3 hr. p.c. Partial relief by food	68	5,430,000	90%	Irritable duodenum, active and reversed peristalsis. Moderate stasis at lower duodenal angle. Swelling of mucosa of proximal jejunum	Amebiasis	Complete relief from pain on second day after vermifuge. Roentgen findings improved 5 days after recheck, normal 8 weeks after vermifuge
5	F 20	Loss of strength and color 9 mo. duration. Heaviness in epigastrium with heartburn	43	1,960,000	20%	Negative	Cardiac dilatation	Roentgen examination normal. No epigastric pain, normal acidity, severe anemia
6	F 18	General weakness	35	2,820,000	45%	Negative	—	Roentgen findings normal. No epigastric pain, normal acidity, marked anemia
7	F 30	Epigastric pain 3–4 hr. p.c. wakes patient at night. Relieved by food and alkalis	33	2,200,000	35%	Negative	Edema of lower extremities	Epigastric pain, although roentgen findings and acidity normal; marked anemia
8	M 28	Heartburn, distention in epigastrium	23	1,890,000	33%	Negative	Pneumonia	Roentgen findings and acidity normal, severe anemia
9	M 30	Epigastric pain rather constant, not relieved by food or alkalis; general weakness	24	4,200,000	70%	Negative	—	Roentgen findings and acidity normal. Epigastric pain not periodic
10	M 36	General weakness, vague abdominal pains for many years	48	3,550,000	50%	Tender and irritable duodenum, active peristalsis	Syphilis, malaria, liver cirrhosis. Wassermann 4 plus	Rather high acidity despite multiple diseases and anemia
11	F 17	Epigastric pain 2 hr. p.c. relieved by food, 2 yr. duration	38	3,750,000	85%	Negative	*B. coli communis* pyelitis	Pain relieved after vermifuge. Roentgen findings and acidity normal
12	F 45	Abdominal pain 5 yr. duration	30	3,550,000	65%	Irritable duodenum	Cholecystectomy 7 yr. duration	Normal acidity with moderate anemia
13	M 45	Epigastric pain 2–3 hr. p.c. Relieved by food and alkalis; 1 yr. duration	87	4,700,000	—	Tender and irritable descending duodenum. Reversed peristalsis	—	Prompt relief after vermifuge. High acidity. Epigastric pain and positive roentgen findings

TABLE I—*Continued*

Case No.	Sex and Age	Chief Complaint and Duration	Free Gastric Acidity	Red Blood Cell Count	Hemoglobin	Roentgen Findings	Complications	Remarks
14	F 35	Epigastric pain, general weakness, palpitation	94	1,840,000	35%	—	Edema of lower extremities	Severe anemia with very high acidity
15	M 55	Epigastric pain 2 hr. p.c. acid eructations, relief by food and alkalis; 30 yr. duration	62	—	—	Gastric and duodenal mucosa swollen. Reversed peristalsis	Gastroenterostomy, 15 yr. previously, with no improvement	Prompt relief after vermifuge. Operation may have been unnecessary, if correct diagnosis had been made
16	M 22	Epigastric pain 2 yr. duration; heartburn	50	4,390,000	80%	—	*Strongyloides stercoralis*	Prompt relief after vermifuge
17	M 25	Epigastric pain 2–3 hr. p.c. relieved by food and alkalis, of 10 yr. duration	50	4,700,000	85%	Swollen mucosa of cap and descending duodenum. Spastic and tender cap. Increased and reversed peristalsis	Amebiasis; diabetes	Prompt relief after vermifuge. Roentgen findings normal 24 days after vermifuge. Acidity falls 11 points
18	M 23	Epigastric pain 9 mo. duration. Palpitation and dyspnea on effort	85	1,210,000	25%	Pylorospasm, slight broadening of mucosa of cap and descending duodenum. Active and reversed peristalsis. Swelling of jejunal mucosa, barium column tends to be segmented	Cardiac dilatation	Roentgen findings show improvement 5 days after vermifuge. Recheck after 8 mo. normal. Prompt relief of pain after vermifuge. Acidity falls 20 points in 8 mo. *Note:* high acidity with severe anemia
19	M 30	Epigastric pain 4 hr. p.c. relieved by alkalis; 1 yr. duration	63	2,420,000	50%	Slight broadening of mucosa. Irritable duodenum. Active and reversed peristalsis	—	Prompt relief after vermifuge. High acidity with anemia. Roentgen findings normal in 16 days
20	F 14	Loss of strength and color plus fever 1½ mo. duration	33	1,380,000	25%	Irritable cap and descending duodenum. Active peristalsis of stomach and duodenum. Diverticulum of stomach. Slight swelling of jejunal mucosa. Loss of "feathery" pattern	Cardiac dilatation. Edema	Normal acidity. Severe anemia. Roentgen examination shows normal duodenum in 11 days
21	M 16	Abdominal pain and epigastric distention	37	5,000,000	90%	Irritable cap with moderate swelling of mucosa. Increased and reversed peristalsis	*Trichostrongylus*	Prompt relief after vermifuge. Recheck roentgenogram after 10 wk. normal. Recurrence due to complication 4 mo. later. Normal again after 4 wk., vermifuge having been repeated
22	M 45	Epigastric pain and distention after meals	66	4,700,000	85%	Irritable duodenum. Active and reversed peristalsis. Swollen jejunal mucosa. Loss of "feathery" pattern	*Strongyloides stercoralis*, spondylitis, appendectomy 2 yr. before	Relief of epigastric pain after vermifuge
23	M 19	Backache, acid eructations and distention	68	—	—	Slightly swollen mucosa of bulb. Irritable duodenum. Active and reversed peristalsis	—	Digestive symptoms disappeared after vermifuge

TABLE I—*Continued*

Case No.	Sex and Age	Chief Complaint and Duration	Free Gastric Acidity	Red Blood Cell Count	Hemoglobin	Roentgen Findings	Complications	Remarks
24	F 25	Swelling of abdomen and lower extremities 9 mo. duration. Epigastric pain 3–4 mo. duration. Heartburn, loss of strength and color	13	840,000	15%	Slightly swollen mucosa of duodenum and jejunum	Cardiac dilatation, ascites, nephritis	Very severe anemia, cardiac dilatation, circulatory failure, extreme weakness, low free acidity, moderate duodenal changes. Roentgen findings normal 21 days after vermifuge. Iron treatment and diet is followed by rise of red blood cells to 2,580,000 and HCl to 30 within 4 wk.
25	M 35	Epigastric pain 1 hr. p.c. especially after heavy meals. Cough of 12 yr. duration	56	4,730,000	85%	Active gastric and duodenal peristalsis with reversed duodenal peristalsis. Swollen mucosa of duodenum and jejunum	Amebiasis	Prompt relief of pain after vermifuge. Roentgen examination after 12 days shows condition rapidly returning to normal

whom proper medical care is not readily available. During the last few years, however, an increasing number of patients from all walks of life, suffering from hookworm disease, have been examined and treated at this institution.

The present report is based on a series of 25 cases of ankylostomiasis in which, in addition to routine clinical and laboratory studies, gastric juice analysis and roentgenologic studies of the gastrointestinal tract were made. Significant data on all cases are given in Table 1.

Twenty-three out of the 25 patients complained of digestive disturbances and abdominal pain. In 10 cases, epigastric pain had a definite relation to meals, coming on one to four hours after ingestion of food. These patients awoke at night with epigastric pain, pain relieved by intake of food and alkalies. Small quantities of soft and easily digestible food relieved the hunger pains while the intake of coarse food or of large quantities of food increased the epigastric pain and discomfort. In none of these patients was there vomiting, hematemesis or melena. It is significant to note that all patients had relief from epigastric pain and distress within twenty-four hours after administration of the vermifuge (mixture of carbon tetrachloride and oil of Chenopodium). In patients whose pain persisted or returned shortly after administration of the vermifuge, it was noted that ova of *Ankylostoma duodenale* were still present in the stools. A second dose of vermifuge produced complete relief from symptoms.

All 25 patients had positive stools for ova of *Ankylostoma duodenale* upon admission, but the stools became ova free before the patients were discharged. Twenty-three of the 25 patients had roentgenologic examination of the gastrointestinal tract. As many of our patients came from relatively distant sections of the country, it was not possible to obtain on all follow-up roentgenologic evidence of cure.

PATHOLOGICAL CHANGES IN THE SMALL INTESTINE

Although hookworms are most frequently located in the jejunum,[15,18,20,21] they may extend proximally up to the pylorus and distally as far as the cecum and ascending colon. As the name implies, one would expect to find the parasites more abundantly in the duodenum. Their presence in varying levels of the duodenum has been frequently observed.[15,21] The parasites have been recovered from aspirated gastric secretions.[6]

One would assume that the nearer the zone of infection is to the pylorus, with more extensive involvement of the duodenal mucosa, the more likely are the symptoms to simulate those of duodenal ulcer and the more marked the roentgen findings in the duodenum are expected to be.

The pathological changes in the walls of the small intestine are due to the combined effect of the reaction to the trauma inflicted upon the mucous membrane by the formidable hooklets of the parasite, secondary bacterial invasion, as well as the effect of the toxin of the parasite.[18,19,20,21]

There are numerous punctate erosions of the mucosa at the site of attachment of the parasite with varying degrees of hemorrhage into the mucosa and submucosa. Leukocytic infiltration is present and edema of the mucosa is also noted. The findings may be summed up essentially as (*a*) trauma, bleeding and accompanying changes, and (*b*) chronic enteritis.[19]

GASTRIC SECRETIONS

As already mentioned, hypochlorhydria or achlorhydria is the common finding in severe anemias. Our observations are in marked variance with this dictum as can readily be seen from Table 1 and Chart 1, demonstrating a marked rise in free gastric acidity above the normal levels. This is well illustrated by Cases 14 and 18, while Cases 20 and 24, showing the severest degree of anemia observed in any of these cases, still maintain an acidity of 33 and 13 in spite of a red blood cell count of 1,380,000 and 840,000 respectively. To our knowledge no striking findings have hitherto been reported on gastric juice of patients with ankylostomiasis.[2,6,11,24*] Garin, *et al.*[6] and Suárez[24] are of the opinion that neither the number of parasites attached to the duodenal mucosa nor the resulting anemia influence the gastric acidity. They have given no correlation between the degree of acidity and the dyspeptic symptoms.

In Chart 1, curve (*1*) represents the free acidity curve plotted from 10 cases of ankylostomiasis with symptoms indicative of duodenal ulcer and with positive roentgen findings in the duodenum. It is higher than the curve for duodenal ulcer. Curve (*2*) is plotted from all the remaining cases of ankylostomiasis reported in this series, other than the 10 already referred to. It is similar to curve (*3*) which is plotted from free acidity curves of 50 cases of active

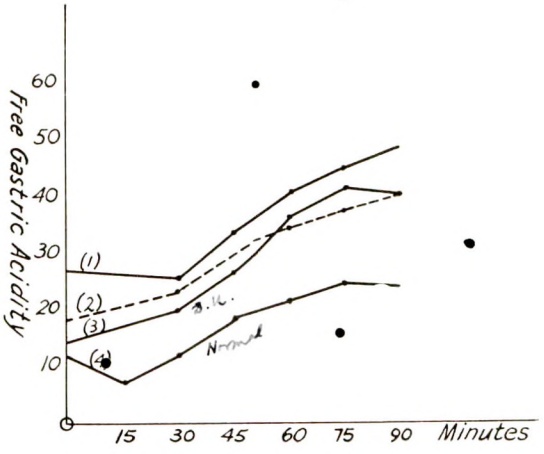


Chart 1. (*1*) free acidity curve plotted from 10 cases of ankylostomiasis with symptoms of duodenal ulcer and positive roentgen findings; (*2*) free acidity curve plotted from all remaining cases; (*3*) free acidity curve of 50 cases of active duodenal ulcer before treatment; (*4*) free acidity curve of 100 healthy medical students.

duodenal ulcer, before treatment, at the American University Hospitals. Curve (*4*), representing a normal level, is based on the free acidity curve of 100 healthy medical students at the University, who are known to be free of ankylostomiasis, or other disease.

ROENTGENOLOGIC OBSERVATIONS

The occurrence of duodenal irritation and duodenal inflammation in the absence of a peptic ulcer is gaining wider recognition in the fields of pathology and clinical medicine as well as of roentgenology. Discussion of this subject is outside the realm of this paper and will be considered elsewhere. Roentgenologic studies of the gastroin-

* Since this paper was read references 2 and 11 have appeared.

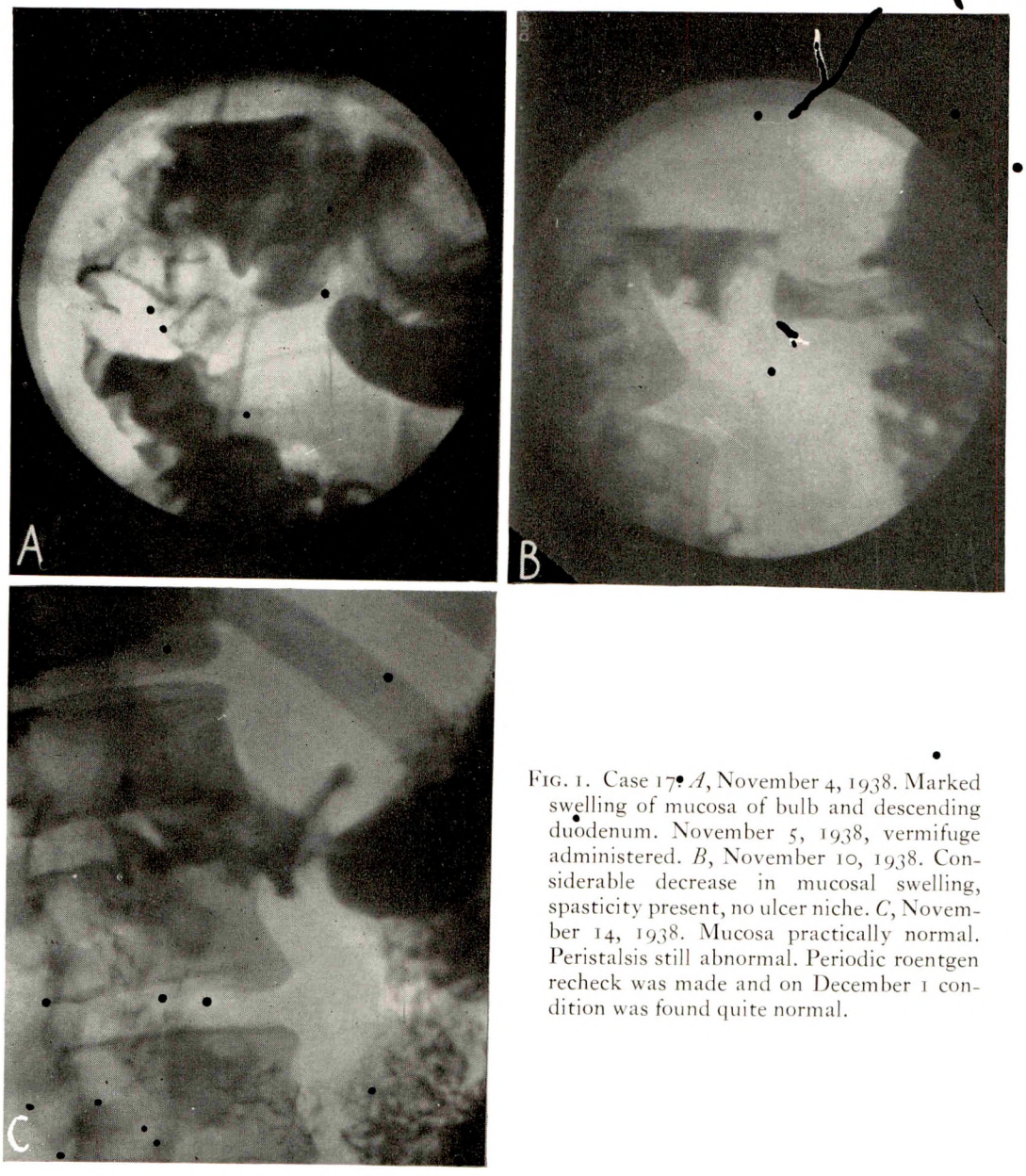


FIG. 1. Case 17. *A*, November 4, 1938. Marked swelling of mucosa of bulb and descending duodenum. November 5, 1938, vermifuge administered. *B*, November 10, 1938. Considerable decrease in mucosal swelling, spasticity present, no ulcer niche. *C*, November 14, 1938. Mucosa practically normal. Peristalsis still abnormal. Periodic roentgen recheck was made and on December 1 condition was found quite normal.

testinal tract of patients with ankylostomal infection reveal, in the majority of cases, certain findings which indicate the presence of definite irritability or inflammation of the duodenum, and sometimes of the jejunum. This varies in degree and location and most probably depends on the severity of the parasitic infestation as well as on the part of the intestines that is most involved.

Of the 25 cases under consideration, 23 were examined roentgenologically. Of these, 17 cases, or 68 per cent, showed definite roentgenologic changes in the duodenum. These changes may be divided into functional and anatomical.

The stomach often presents the same roentgenologic aspects seen in association with a duodenal ulcer or duodenitis. Peristaltic activity is increased and gastric evacuation is accelerated. At times, slightly prolonged initial pylorospasm is observed.

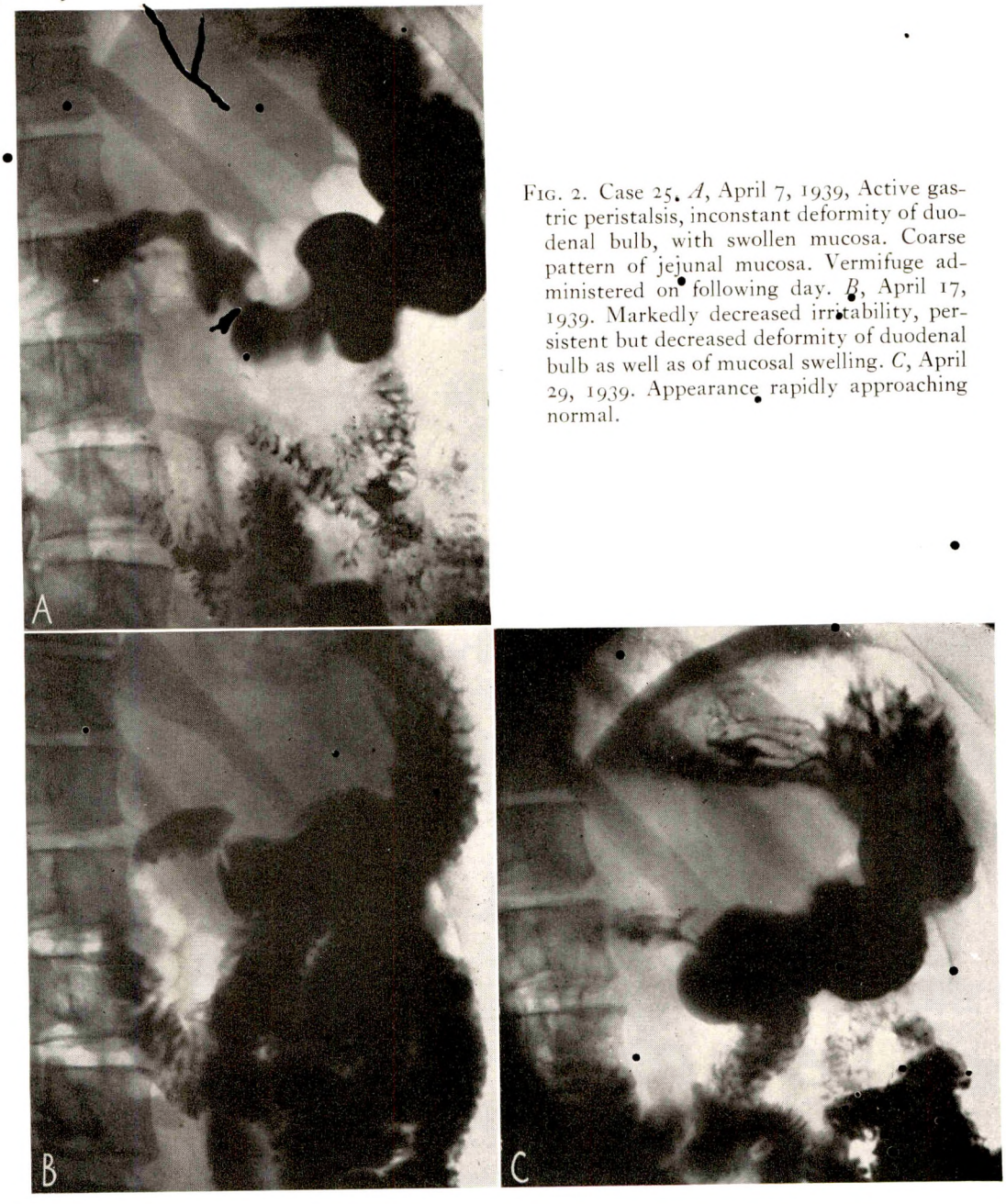


FIG. 2. Case 25. *A*, April 7, 1939, Active gastric peristalsis, inconstant deformity of duodenal bulb, with swollen mucosa. Coarse pattern of jejunal mucosa. Vermifuge administered on following day. *B*, April 17, 1939. Markedly decreased irritability, persistent but decreased deformity of duodenal bulb as well as of mucosal swelling. *C*, April 29, 1939. Appearance rapidly approaching normal.

As the functional changes are the ones most constantly observed, the roentgenoscopic part of the examination is all the more important. Roentgenographic records are of diagnostic value when definite changes in the mucosa are demonstrable.

Functional Changes. These may be motor and secretory.

The duodenum as a whole is irritable. The contrast medium is carried rapidly forward by active peristalsis. Often reversed peristalsis sends the barium backwards, moving it back and forth several times, producing a "pendulum effect." This latter finding is not constantly present, may be observed less commonly in normal patients, and cannot be considered diagnostic. In this connection, our findings are at vari-

ance with those reported by other observers[9,10] who consider this sign of great diagnostic significance. Reversed peristalsis was found in 12 of the 23 cases roentgenologically examined. Varying degrees of spasticity of the duodenal bulb are observed. Mild transitory stasis at the lower duodenal angle is noted at times.

Repeated roentgenoscopic observations at frequent intervals after the administration of antihelminthics demonstrates a steady decrease in the intensity of these signs as the duodenum gradually returns to normal.

No gastric retention has been observed. Increased secretion in the stomach and duodenum tends to decrease the density of the contrast medium. Tenderness is elicited on pressure over the duodenum, especially over the bulb when the latter is involved. The epigastrium is also tender on pressure.

Anatomical Changes. Varying degrees of swelling of the mucosa with alteration of its pattern was observed roentgenologically in 8, or 31 per cent, of the cases (Fig. 1 and 2). The occurrence of spasticity together with swelling of the mucosa and accompanying deformity of the duodenal bulb renders differential diagnosis from ulcer difficult.

The absence of a definite niche, the inconstancy of the deformity and the rapid return to normal after the administration of a vermifuge eliminates every doubt as to whether there had been an ulcer or a nonparasitic duodenitis. After the administration of the vermifuge, these patients were allowed their regular diet. Thus it is not possible to attribute any of the improvement so obtained to the effect of a special dietary regimen. In certain instances, the finding of ova of *Ankylostoma* in the stools may be the only means of differentiation between an ankylostomal duodenitis and a non-ankylostomal duodenitis or a condition with marked irritability of the duodenum.

This is mentioned to emphasize the fact that although the above described roentgenoscopic and roentgenographic findings, when present, are typical in ankylostomal infection, they are by no means characteristic or pathognomonic of the condition.

In the jejunum, alterations from the normal were occasionally met with in these cases. The usual "feathery" appearance of the contrast medium in the jejunal loops is lost, the pattern is coarse, and the mucosa is swollen. At times, in later stages, the contrast medium tends to appear in more or less isolated solid columns or masses. It is not possible to evaluate the significance of this finding in the light of changes due to vitamin deficiency when so few observations have been made.[8,16,23*]

Following the administration of antihelminthic treatment, the patient's symptoms cleared up almost immediately, pain usually disappearing by the second day. Roentgenologically the return to normal is much slower. Although localized tenderness is the first sign to disappear, roentgen evidence of duodenitis and duodenal irritation remains for some time, and if unduly persistent, is an indication of continued infection or reinfection.

Only after a thorough and effective treatment, with repeated negative stool reports, may a cure be assumed. Roentgenological confirmation of a cure is usually obtained in from eleven to twenty-four days after the administration of the vermifuge. Evidence of improvement, both roentgenoscopic and roentgenographic, is apparent as early as the third to the fifth day.

In some cases it was not possible to make a roentgenologic re-examination until a few weeks or months had elapsed. It is not to be inferred that such a long time was needed for a cure. It means that the patients were late returning for their re-examination, while a few never came.

Of the 17 cases with positive roentgenological findings in the duodenum, 4 had a normal gastric acidity, 2 were in the limits of high normal, 8 had definite hyperchlorhydria, and 3 a "towering" high free acidity. The latter 3 were 87, 94 and 85 respec-

* Since this paper was read references 8 and 16 have appeared.

tively, the last 2 having red counts of 1,840,000 and 1,270,000 respectively. Ten cases had a severe anemia varying between 800,000 and 2,820,000 red blood cells per cubic millimeter.

Four had epigastric pain which had no definite relation to meals. Ten had symptoms highly suggestive or indicative of peptic ulcer, pain coming on from one to three hours after meals, relieved partially or completely by food or alkalies or both. On the other hand, 2 cases with symptoms suggestive of duodenal ulcer had normal gastric acidity and a normal duodenum by roentgen examination.

We feel that these studies have a direct bearing on the problem of differential diagnosis and treatment of patients complaining of symptoms of, or symptoms simulating a duodenal ulcer.

Although ankylostomiasis is not frequent in this country, after reviewing these cases it seems desirable to keep it in mind, especially where patients have such different and varied occupations and come from such different classes of society.

Most gratifying results may be obtained through a correct etiologic diagnosis followed by an effective and specific treatment. Compare, on the one hand, a patient with an ankylostomal duodenitis with another who has a non-ankylostomal duodenitis or duodenal ulcer. Both patients present essentially similar symptoms.

The former is relieved of symptoms on the second day after the administration of the vermifuge and is completely cured in from eleven to twenty-four days.* The patient's activities are limited only during the period when the vermifuge is administered, after which normal activity and diet are resumed. On the other hand, a patient suffering from a non-ankylostomal duodenitis or a duodenal ulcer will require a prolonged expensive and strict dietary regimen and in most cases the patient's activities are restricted for a relatively longer period.

* It is evident that "cure" refers to the condition of the duodenum and accompanying signs and symptoms. Severe anemia and other complications accompanying long-standing and severe infections present aspects of the disease not under consideration in this paper. Such conditions did not come up for primary consideration in this series of cases.

CONCLUSIONS

Gastrointestinal disturbances caused by hookworm disease may produce symptoms closely simulating duodenal ulcer.

Estimation of free gastric acidity shows a rise to a level higher than that obtained in duodenal ulcer. In spite of varying degrees of severe anemia, such a high gastric acidity is maintained. Roentgenological studies of these cases show evidence of swelling of the duodenal mucosa, inconstant deformity of the duodenal bulb (duodenitis without ulcer niche), hyperperistalsis of stomach and duodenum, and, commonly, reversed peristalsis of the duodenum without obstruction. Administration of a vermifuge successfully results in the elimination of epigastric pain within twenty-four hours, and the restoration of the duodenal wall in from eleven to twenty-four days.

REFERENCES

1. Ashburn, C. W. Hookworm disease simulating duodenal ulcer. *South. Med. & Surg.*, 1932, *94*, 15.
2. Azmy Pasha, S., and Zanaty, A. F. Iron and blood transfusion therapy in ancylostoma anaemia. *J. Trop. Med.*, 1939, *42*, 263–271.
3. Chandler, A. C. Hookworm Disease. Macmillan Co., New York 1929.
4. Craig, C. F., and Faust, E. C. Clinical Parasitology. Lea & Febiger, Philadelphia, 1937.
5. Faust, E. C. Symptomatology, diagnosis and treatment of strongyloides infection. *J. Am. M. Ass.*, 1932, *98*, 2276–2277.
6. Garin, C., Rousset, J., and Gonthier, B. Les fonctions gastriques dans l'ankylostomose. *Lyon méd.*, 1930, *146*, 3–9.
7. Gibbes, J. H. Symptoms suggestive of duodenal ulcer arising from hookworm infection. *J. South Carolina Med. Ass.*, 1934, *30*, 102–106.
8. Golden, R. Small intestine in vitamin B deficiency. *J. Am. M. Ass.*, 1941, *117*, 913–917.
9. Henderson, W. F. Antiperistalsis in duodenum; presumptive sign of intestinal parasitosis; preliminary report. *J. Am. M. Ass.*, 1925, *84*, 493–494.
10. Henderson, W. F. Duodenal antiperistalsis; further observations. *J. Am. M. Ass.*, 1925. *85*, 1462–1465.
11. Hoff, H., and Shaby, J. A. Nervous complica-

tions in ankylostomiasis. *J. Trop. Med.*, 1939, *42*, 360–362.

12. HUDSON, E. H., and YOUNG, A. L. Hookworm disease in the Arab of the Middle Euphrates. *Ann. Trop. Med.*, 1933, *27*, 207–212.
13. KERLEY, P. Recent Advances in Radiology. Second edition. P. Blakiston's Son & Co., Philadelphia, 1936.
14. KIRKLIN, B. R. Duodenitis and its roentgenological characteristics. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 581–587.
15. MANSON-BAHR, P. H. Manson's Tropical Disease. William Wood & Co., Baltimore, 1936.
16. MACKENZIE, A. Deficiency of vitamin B_1 in hookworm anaemia. *Lancet*, 1939, *1*, 1143–1145.
17. PELLEGRINI, G., and FACCI-TOSATTI, F. Studio clinico e radiologico di alcune alterazioni del duodeno provocate dall'anchilostoma duodenale. *Arch. ital. d. mal. d. app. diger.*, 1934, *2*, 599–630.
18. ROGERS, L., and MEGAW, J. W. Tropical Medicine. Second edition. J. & A. Churchill, Ltd., London, 1935.
19. ROTTER, W. Ueber die histologischen Veränderungen des Dünndarms bei Ankylostomiasis. *Virchow's Arch. f. path. Anat.*, 1931, *280*, 587–594.
20. RUGE, R. MÜHLENS, P., and ZUR VERTH. Krankheiten und Hygiene der warmen Länder. Dr. Werner Klinkhardt, Leipzig, 1926.
21. SCHAPIRO, L., and NAUCK, E. G. Observations on hookworm disease in Costa Rica based on postmortem findings. *Am. J. Hyg.*, 1931, *14*, 705–714.
22. SENSENICH, R. L. Duodenitis and motor disorders of duodenum. *J. Indiana Med. Ass.*, 1932, *25*, 117–123.
23. SNELL, A. M., and CAMP, J. D. Chronic idopathic steatorrhea; roentgenologic observations. *Arch. Int. Med.*, 1934, *53*, 615–629.
24. SUÁREZ, R. M. Clinical aspects of uncinariasis. *Puerto Rico J. Pub. Health & Trop. Med.*, 1933, *8*, 299–337.
25. YENIKOMSHIAN, H. A., and BERBERIAN, D. A. Preliminary report on incidence of hookworm disease in Syria and Lebanon. *Tr. Roy. Soc. Trop. Med. & Hyg.*, 1932, *25*, 399–406.

Vol. 49, No. 1

DEVELOPMENT, CLINICAL MANIFESTATIONS, AND TREATMENT OF RHEUMATOID ARTHRITIS OF THE APOPHYSEAL INTERVERTEBRAL JOINTS

By ALBERT OPPENHEIMER, M.D.*

Department of Roentgenology, School of Medicine, American University of Beirut

BEIRUT, LEBANON, SYRIA

I. OBJECT OF STUDY

IN ANALYZING diseases which are grouped with arthritis of the spine, it is useful to make a distinction between lesions of the vertebral symphyses and lesions of the apophyseal joints. The name *vertebral symphysis* is used in this paper to designate the articulation between two vertebral bodies and the intervening vertebral disc, since this junction is a synchondrosis or symphysis like the pubic symphysis.[1] The *apophyseal joint*, which connects contiguous articular processes, is a synovial or diarthrodial articulation like the joints of the limbs. This anatomical difference has its clinical significance. Previous observations suggested that the mobility of the spine depends on the integrity of the apophyseal joints rather than on the condition of the vertebral symphyses and ligaments.[16,19] In continuation of these studies a group of patients has been examined in whom severe stiffness of the back or neck was present, together with other variable symptoms conforming to the clinical picture of Strümpell-Marie disease or rhizomelic spondylosis. The anatomical lesion associated with this syndrome is quite distinctive, but has been variously interpreted, e.g., as a decalcification of bone followed by ossification of fibrous tissue,[12] a syndesmotic type of spondylitis;[24] an ossifying disease of the vertebral ligaments;[9] an atrophic spondylitis;[7] or an ankylosing arthritis of the apophyseal joints.[5,16,24] All of these theories are based upon postmortem findings. But since "one does not die from rhizomelic spondylosis,"[12] autopsy usually discloses only the advanced stages during which the primary lesion is almost invariably overgrown by reparative or incidental changes. Hence the pathology of the initial lesion is not yet sufficiently known, and these anatomical findings do not explain adequately the clinical manifestations which were present during earlier stages. In order to correlate clinical and anatomical findings it is necessary to compare the clinical manifestations present at any one time with the lesion that is present at the same time. If, from a study of these correlations, we could learn to recognize the anatomic lesion in its incipient phase, we may hope perhaps to treat more effectively this disease which has hitherto been incurable because its diagnosis is usually made at an advanced stage, when restitution to the normal can no longer be expected. On the basis of observations about the gradual evolution of the clinical and of the corresponding anatomical pictures, the attempt is made in this paper to answer three questions:

1. In which part of the vertebra is the primary lesion localized and of what nature is it?
2. What produces the characteristic stiffness of the back and neck present in this disease?
3. Can treatment be directed by the findings?

II. METHOD

Fifty patients with severe stiffness of the back and/or neck, and with other variable symptoms, were examined during the years 1934–1941; 12 of them at least twice at different intervals. The findings were compared with those of two control series: (1) 50 patients with stiffness of back and/or neck not caused by vertebral disease; (2) 50 patients with lesions confined to the vertebral symphyses, with or without clinical symptoms. In addition to

* Now at Laconia Hospital, Laconia, New Hampshire.

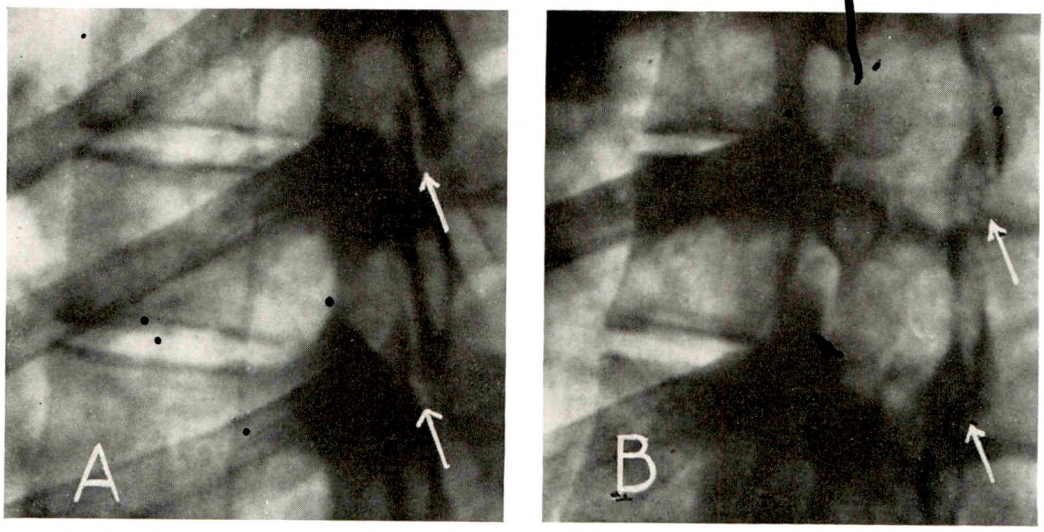


FIG. 1. A picture falsely suggestive of a lesion is produced by a slight technical inaccuracy. Thoracic spine of a healthy woman aged twenty-one. *A*, correct incidence at an angle of 18°. Joints normal (arrows). *B*, deviation of 4° from the position shown in *A* renders the joint spaces invisible, thereby suggesting ankylosis (arrows).

physical and laboratory examinations a study of vertebral movements was made in every case and was recorded on photographs, roentgenograms, or both, in 39 patients of the first group, and in 42 cases of the two control series. Roentgenograms were always made of the entire spine, regardless of the seat of symptoms. The

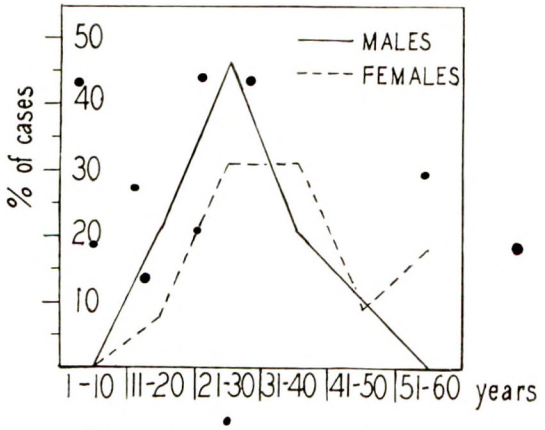


FIG. 2. Age distribution of onset of vertebral symptoms.

technique has been previously described.[16] Accurate positioning is necessary. Since the facets of the articular processes vary in direction[8,11,16] the findings have to be verified in many cases on roentgenograms repeated at slightly different angles. Deviations from the angle required in the individual case may result in appearances falsely suggestive of ankylosis (Fig. 1). Owing to the general limitations of roentgen interpretation some findings remain ambiguous even after several examinations; 5 such cases have not been included in this report.

III. INCIDENCE AND DISTRIBUTION

The 50 cases represent 3.2 per cent of all vertebral lesions observed between 1934 and 1941 in the Department of Roentgenology of the American University Hospitals, Beirut. Twelve of the patients were female (24 per cent). Both the total incidence and the percentage of female cases are greater than reported by other writers.[6,9,11,20] Although the roentgen technique used in our series discloses slight and incipient lesions which cannot always be shown on conventional roentgenograms,[16] this can hardly account for the relatively large number of cases observed in Beirut, since, using the same technique, I found that in Europe and in the United States these cases total 0.9 and 1.1 per cent re-

spectively of all vertebral lesions which I examined.

The age distribution (Fig. 2) shows a peak for the onset of symptoms in the second decade. The tendency to onset at a slightly later period in women, as seen on the graph, corresponds to the observation that all types of arthritis begin later in women than in men.[20] The onset of symptoms other than vertebral has not been taken into account here. The "prespondylitic" manifestations[6] ranged from recurrent muscle ache to severe arthritis of peripheral joints; but their real nature could not always be inferred from the histories or clinical data.

IV. ETIOLOGY

The histories and findings failed to suggest tangible etiologic factors in 22 instances. For the remaining 28 patients (56 per cent) the probable etiology is presented in Table 1.

Column 1 includes patients with a gonorrheal infection which preceded the onset of vertebral or articular symptoms by not more than four months, as well as patients with chronic gonorrhea proved bacteriologically. Three cases with a history of neisserian infection are not included because of an interval of over four years between infection and onset of symptoms, in the absence of chronic gonorrhea. Four other patients acquired gonorrhea several years after the onset of vertebral pain. Of the 2 persons with a history of trauma, column 2, one had fallen onto his back from a height of about 12 ft., the other had been severely beaten on the back. Both stated, and witnesses confirmed, that pain and stiffness of the back began within one week after the trauma. This unusual etiology was also recorded by Pierre Marie in one instance.[14] Under the heading "exposure," in column 3, patients are listed who, prior to the onset of symptoms, had been working barefooted in irrigated fields during winter, or had been flooded, trapped in snow, or the like. Two such cases are not included, being presented in column 4 because they developed rheumatic fever immediately after an exposure of this kind. In the patients of column 4, with rheumatic fever, the vertebral disease was preceded by pain and swelling of several peripheral joints and fever of not less than five weeks' duration; in 3 of these cases, one or several peripheral joints were still swollen, and body temperature was still elevated, at the time when the spine was examined. The cases classified under the heading "chronic sinus," in column 5, form a distinct group with findings, apparently not yet described, to be reported separately.* In these patients the vertebral lesion was confined to spinal segments located at the level of a chronic discharging lesion of the soft tissues of the back or neck. For instance, in a patient who had suffered from recurrent carbuncles of the neck for about five years, only the cervical vertebrae were involved. In the other cases the lumbar vertebrae were found diseased in that region in which the soft tissue lesion was located. Since there were no signs of vertebral tuberculosis, nor of a macroscopic connection between the spine and the fistula, it was assumed that the vertebral lesion was not the cause, but the result, of the soft tissue lesion, in analogy to the ankylosis of the wrist joint which sometimes develops as a sequela of whitlow of a finger tip.[13]

Foci of infection in the teeth, tonsils, or paranasal sinuses were noted in 6 patients of the rheumatic fever group. Sundry other infections, such as chronic malaria, recurrent cystitis, amebiasis, were present in

TABLE I

CAUSE OF THE CONDITION

1 Gonorrhea	2 Trauma	3 Exposure to Cold	4 Rheumatic Fever	5 Chronic Sinus
10=20%	2=4%	3=6%	9=18%	4=8%

* Oppenheimer, A. Paravertebral abscesses associated with Strümpell-Marie disease. *J. Bone & Joint Surg.*, January, 1943.

TABLE II

SYNOPSIS OF FINDINGS

Case No. (X-ray No.)	Age Sex	Duration of Vertebral Symptoms	Stage	Involved Region	Apophyseal Joints			Vertebral Bodies	Discs	Ligaments†			Joints of Trunk and Limbs				Pubic symphysis	Pain		Rigidity
					Articular processes	Facets	Joint space			Longitudinal	Flava	Spinous	Costovertebral	Sacroiliac	Hips	Limbs		Local	Radicular	
1 (6-805)	45 m	12 days	I	L III/IV	rarefied	eroded	narrow	normal	normal	–	–	–	normal	normal	normal	normal	normal	+	–	+
2 (8-2240)	27 m	3 mo.	I	L II/III III/IV	raref.	eroded	narrow	normal	normal	–	–	–	normal	eburnat., narrow	normal	normal	normal	+	–	+
3 (8-2934)	28 f	20 days	I	L II/III	raref.	eroded	narrow	normal	normal	–	–	–	normal	blurred	normal	normal	normal	+	–	+
4 (8-2950)	35 f	2 yr.	I	C V, L II/III	raref.	normal?	narrow	normal	normal	–	–	–	normal	normal	normal	normal	normal	+	+	+
5 (9-905)	35 m	3 mo.	I	L IV/V	raref. ++	invis. (raref.)	narrow	normal	normal	–	–	–	normal	normal	normal	normal	normal	+	+	+
6 (8-3510)	39 m	5 yr.	II	C D L	normal	rough	narrow	normal	normal	(+)	((+))	+D	rough	(ankyl.)	normal	normal	normal	–	–	+
7 (8-1723)	54 m	16 yr.	II	C D L	normal	rough; circl.*	narrow	normal	normal	(+)	(+)	(+)	normal	ankyl.	normal	normal	normal	(+) neck	–	+
8 (5-156)	30 m	5 yr.	II	L	raref.	ragged, some ankyl.	narrow	raref.	normal	–	+	(+)	normal	ankyl.	normal	normal	normal	+	+	+
9 (6-1406)	30 m	3 yr.	II	C D L	raref.	eroded	narrow	raref.	normal	–	–	–	normal	ragged	normal	normal	normal	+	–	+
10 (7-1901)	35 m	7 yr.	II	D L	(raref.)	ragged	normal	(raref.)	normal	+L	–	+D	normal	ragged	normal	normal	normal	+	–	+
11 (8-254)	45 f	10 yr.	II	C L	(raref.)	eburnated	very narrow	(raref.)	normal	–	–	–	rough	ankyl.	L ankyl.	knees	normal	+	–	+
12 (8-2788)	60 f	8 yr.	II	C L	raref.	ragged	narrow	raref.	normal	–	–	–	normal	almost ankyl.	narrow	normal	normal	+	–	+
13 (8-2795)	37 m	9 yr.	II	C D L	raref.	D ankyl.	narrow	raref.	normal	–	–	–	rough	ankyl.	normal	normal	normal	(+)	–	+
14 (9-205)	15 m	2 yr.	II	L	raref.	rough	very narrow	raref.	normal	–	–	–	normal	(ankyl.)	narrow	normal	normal	+	–	+
15 (9-2671)	28 m	15 days	II	L	(raref.)	eroded	very narrow	(raref.)	normal	+	–	–	normal	normal eburnat.	normal	normal	normal	+	–	+
16 (8-1390)	35 m	2 yr.	II	C D L	dense	circl.*	very narrow	normal	normal	–	–	–	normal	ankyl.	normal	normal	normal	+	+	+
17 (8-396)	41 m	5 yr.	II	C D L	raref.	eroded, eburnated	very narrow	raref.	normal	–	–	–	normal	(ankyl.)	normal	normal	normal	+	–	+
18 (6-1568)	57 f	5 yr.	II	C D L	normal	rough	very narrow	(raref.)	normal	+	–	–	normal	normal	narrow	knees, hands, feet	normal	+	+	+
19 (5-13703)	30 f	2 yr.	II	L	normal	rough	very narrow	normal	normal	+	+	–	normal	(ankyl.)	normal	normal	normal	+	–	+
20 (7-2114)	16 m	1½ yr.	II/III	C++ L+	raref.	eroded	almost gone	raref.	normal	–	–	–	normal	eburnated, ragged	normal	normal	normal	+	–	+
21 (7-1993)	35 f	7 yr.	II	C++ D L+	raref.	eroded	almost gone	raref.	normal	+	–	(+)	normal	(ankyl.)	(ankyl.)	normal	normal	+	–	+
22 (8-789)	20 m	3 yr.	II	D L	raref.	eroded	narrow	raref.	normal	–	–	–	rough	eburnated, ragged	normal	normal	normal	+	+	+
23 (9-1621)	40 m	4 yr.	II	L	normal	circl.*	narrow	normal	normal	–	–	–	normal	eburnated, ragged	normal	normal	normal	+	–	+

The parentheses indicate that the change in question is of a moderate degree.

* circl. = circling ankylosis. † the sign, –, means that the ligaments are not visible; the sign, +, means that the ligaments are ossified.

24 (9-1883)	29 m	2 yr.	II	C L	raref.	eroded, circl.*	very narrow	raref.	normal	−	−	−	normal	ragged	narrow ragged	normal	normal	+	+	+
25 (8-3240)	38 f	6 yr.	II	C D L	raref.	eroded	narrow	raref.	normal	(+)	+	+	(ankyl.)	ankyl.	(ankyl.)	All periph. joints	raref.	+	−	+
26 (7-2909)	36 m	7 yr.	II	C D L	raref.	eroded, circl.*	very narrow	raref.	normal	+	−	−	(ankyl.)	ragged cond.	(ankyl.)	normal	raref.	+	−	+
27 (8-1806)	50 f	12 yr.	II	C D L	raref.	ragged	very narrow	raref.	normal	+	−	−	(ankyl.)	ragged	(ankyl.)	normal	raref.	+	−	+
28 (8-2683)	65 m	10 yr.	II	L	raref.	ragged	very narrow	raref.	normal	(+)	−	−	normal	normal	(ankyl.)	normal	normal	−	−	+
29 (8-3750)	39 m	14 yr.	II	L	dense	rough, circl.*	very narrow	normal	normal	−	(+)	−	normal	ankyl.	(ankyl.)	normal	normal	+	−	+
30 (7- 469)	35 m	4 yr.	III	L		ankylosed		normal	normal	+	+	−	normal	ragged	(ankyl.)	normal	normal	−	−	+
31 (9-1438)	32 m	9 yr.	III	D L		(ankylosed)		normal	normal	+	+	−	ankyl.	ankyl.	(ankyl.)	normal	normal	+	−	+
32 (8- 620)	25 m	3 yr.	III	D L		ankylosed		raref.	normal	−	−	−	normal	ragged	(ankyl.)	normal	normal	+	−	+
33 (7-1436)	36 m	6 yr.	III	D L		ankylosed	circl.*	raref.	normal	+	+	−	ankyl.	(ankyl.)	(ankyl.)	normal	normal	+	−	+
34 (3-9407)	24 m	2 yr.	III	D L		ankylosed		normal	normal	(+)	−	−	ankyl.	(ankyl.)	(ankyl.)	knee	normal	+	−	+
35 (8-1114)	30 m	3 yr.	III	D L		ankylosed		normal	normal	(+)	+	−	normal	ankyl.	(ankyl.)	normal	normal	+	+	+
36 (8-2207)	27 m	3 yr.	III	L		ankylosed		raref.	normal	+	−	−	normal	ankyl.	(ankyl.)	normal	normal	+	+	+
37 (8-2367)	60 m	42 yr.	III	C D L		ankylosed		normal	normal	+	+	+	(ankyl.)	ankyl.	(ankyl.)	normal	normal	−	−	+
38 (8-2773)	38 m	2 yr.	III	C D L		ankylosed		normal	normal	+	+	+	ankyl.	ankyl.	(ankyl.)	knees, should.	raref.	+	−	+
39 (8-3175)	38 m	6 yr.	III	C D L		ankylosed		raref.	normal	−	+	(+)	ankyl.	ragged	(ankyl.)	normal	raref.	+	+	+
40 (8-3391)	38 m	3 yr.	III	D L		ankylosed		normal	normal	(+)	+	+	normal	ankyl.	(ankyl.)	normal	normal	+	+	+
41 (9- 331)	29 m	15 yr.	III	D L		ankylosed		normal	normal	−	+	+	normal	ankyl.	(ankyl.)	normal	normal	−	−	+
42 (9-1376)	30 m	15 yr.	III	D L		ankylosed		raref.	normal	(+)	(+)	(+)	ankyl.	ankyl.	narrow	normal	normal	+	+	+
43 (9-2629)	56 m	10 yr.	III	C D L		ankylosed		raref.	normal	(+)	+	−	ankyl.	ragged	narrow	normal	normal	−	−	+
44 (8- 149)	24 m	5 yr.	III	C		ankylosed		normal	normal	+	+	−	normal	normal	narrow	hands	normal	neck +	+	+
45 (9-1829)	26 m	1 yr.	III	D L		ankylosed		normal	normal	−	+	−	normal	ragged	narrow	knees	normal	−	−	+
46 (8-3059)	32 m	10 yr.	III	D L		ankylosed		raref.	normal	−	+	−	normal	ragged	ragged, narrow	normal	normal	+	−	+
47 (7- 771)	30 f	1 yr.	III	C D L		ankylosed		raref.	normal	−	+	−	normal	ragged	ragged	knee, ankle	raref.	+	+	+
48 (7-2705)	30 f	17 yr.	III	C D L		ankylosed		normal	normal	−	−	−	normal	ragged	ankyl.	elbows, knees, hands	normal	−	−	+
49 (7- 363)	55 f	9 yr.	III	L		ankylosed		normal	normal	−	+	−	normal	normal	ankyl.	normal	raref.	+	+	+
50 (6- 669)	60 m	15 yr.	III	C D L		ankylosed		normal	normal	+	+	+	?	ankyl.	narrow	normal	normal	−	−	+

some other patients. Chronic pulmonary lesions, recorded by early investigators,[3,22] were not observed in this series, although I observed the coexistence of lung abscess with Strümpell-Marie disease in 2 cases not included in this report. The influence of hereditary, endocrine, or metabolic factors could not be ascertained; none of the patients was a member of a "rheumatic" family. The occupation of the patients did not seem to play a part: there were 10 tradesmen, 8 artisans, 6 laborers, 5 peasants, 5 professional men, 8 housewives, and 8 persons without occupation in this series.

The patients came from various parts of the Near East which differ considerably in climate: the desert, seashore, plains, and high mountains. Hence a distinctive climatic factor can hardly account for the high incidence of Strümpell-Marie disease in this part of the world. But since the "macro-climate" may be less important than the "micro-climate" in the etiology of rheumatism,[21] one may speculate whether the custom of the Near East people to sleep on blankets or thin mattresses placed on stone floors, together with the absence of heating appliances, may induce rheumatic disease in susceptible persons. In most parts of the Near East, winter is a rainy rather than a cold season; but owing to the excessive humidity during this period the houses are damp and chilly for several months of the year. Most foreigners, therefore, find the winter harder to bear in Syria than, e.g. in New England or Canada. During winter the Oriental often puts on his overcoat when he enters a house, to take it off again when he leaves. Of course, no conclusions can be drawn from such general impressions.

V. THE ESSENTIAL LESION AND ITS DEVELOPMENT

According to the findings presented in Table II, lesions of the apophyseal joints were demonstrable in all the 50 cases (100 per cent); in 9 of these (18 per cent) no other parts of the vertebrae showed evi-

TABLE III

STRÜMPELL-MARIE DISEASE: FINDINGS RECORDED IN THE CLASSICAL PAPERS

Author	Clinical Findings						Postmortem Findings						Remarks
	Onset		Rigidity	Pain		Course	Curvature	Softening of bone	Vertebral bodies connected by ossified ligaments	Apophyseal joints ankylosed	Costovertebral joints ankylosed	Hip joints involved	
	in	at age		local	radicular								
Connor (1700)	No clinical data known						kyphosis	+	+	+	+	?	Incomplete skeleton found in church-yard
Fagge (1876)	?	30	+	−	+	?	kyphosis	+	−	+	+	+	Bronchiectases
Strümpell (1897)	back	3rd decade	+	−	−	ascending from lower back upward	straight back	No postmortem					Emphasizes absence of severe pain
Marie (1898)	knee, neck, back	about 30 yr.	+	+	±	ascending and descending	straight, kyphotic or Z-shaped	No postmortem					First paper in which the disease was defined as a clinical entity
Marie and Léri (1899)	back or small joints	about 30 yr.	+	+	+	ascending	variable	−	−	+	?	not examined	Autopsy incomplete
Léri (1905)	No clinical data recorded						kyphosis	+	−	+	+	+	First complete autopsy and anatomic definition of disease

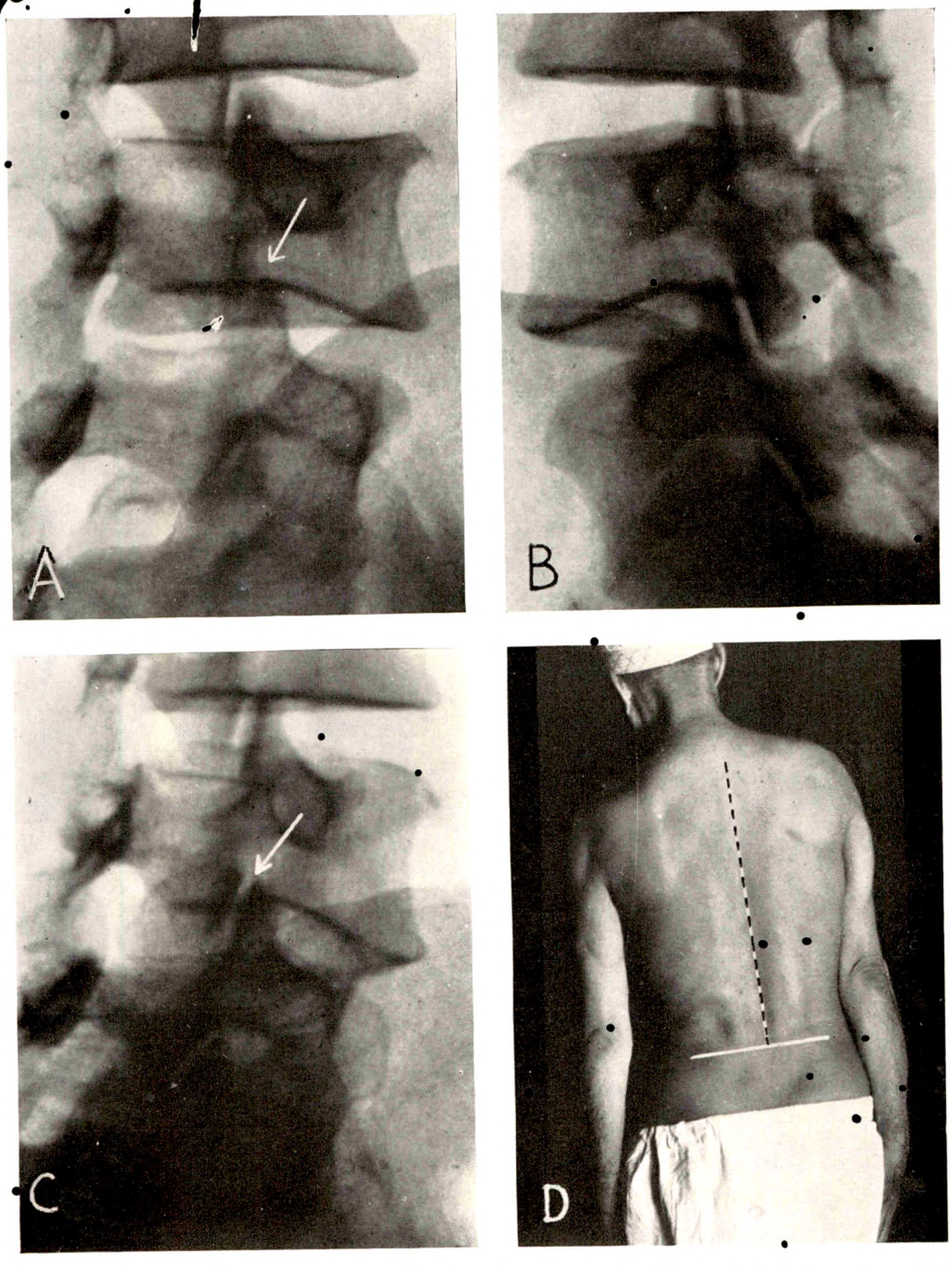


FIG. 3. Case 5. Stage 1. *A*, severe rarefaction of the articular processes of the left 5th lumbar apophyseal joint; joint space invisible owing to the dissolution of the bony outlines (arrow). *B*, normal right side for comparison. *C*, seven weeks later, one month after termination of roentgen therapy, the involved joint has resumed normal appearances (arrow). *D*, maximum amount of sidewards flexion of which the patient was capable at the time when roentgenograms *A* and *B* were taken. Slight lateral bending of the body was achieved by means of lifting of the pelvis on the convex side (horizontal line), but the spine itself was immovable (vertical line). The patient was bedfast owing to incapacitating pain in lower back. Complete recovery occurred within three weeks after beginning of roentgen therapy. The patient has been free of symptoms for over two years since.

TABLE IV

SERIAL ROENTGEN EXAMINATIONS

Case	Date	Observations
1	Feb. 19, 1936	Lumbar articular processes rarefied; lumbar facets scalloped, with narrowed joint spaces. Lig. flav. and longit. lig. at L IV/V ossified. Lumbar vertebral bodies rarefied. Sacroiliacs ragged. Discs normal. Cervical and thoracic regions not examined.
	Dec. 1, 1937	All lumbar apophyseal joints now ankylosed. Lig. flav. and long. lig. now ossified from L I to L V. Sacroiliacs in beginning ankylosis. The thoracic vertebrae show the same changes that were previously present in the lumbar vertebrae. Cervical spine normal.
	Feb. 3, 1938	Lumbar spine unchanged. Thoracic apophyseal joints now ankylosed; with ossification of the thoracic longit. lig. and lig. flava. Cervical apophyseal joint spaces slightly narrowed, with beginning ossification of long. lig.
	Aug. 7, 1940	Practically unchanged.
2	Nov. 22, 1938	Lumbar and thoracic apophyseal joints ankylosed, with rarefied articular processes, and rarefied vertebral bodies. Cervical spine normal. Sacroiliacs ragged. No ossification of ligaments.
	May 1, 1939	Entirely unchanged.
3	May 6, 1937	Lumbar articular processes rarefied, with ragged facets and narrow joint spaces. Thoracic apophyseal joints ankylosed. Cervical spine normal. Lumbar and thoracic vertebral bodies rarefied. Lumbar lig. flava ossified; thoracic longit. lig. ossified at D XI–XII. All other ligaments normal. Sacroiliacs ragged.
	May 27, 1939	Lumbar apophyseal joints now ankylosed. Lumbar long. lig. ossified. Sacroiliacs ankylosed. Otherwise unchanged.
4	Apr. 2, 1939	The 2nd lumbar and the 5th cervical apophyseal joints have rarefied articular processes, narrow joint spaces, and blurred outlines. Spine otherwise normal. Sacroiliacs normal.
	May 19, 1939	(After roentgen therapy.) Unchanged.
	Apr. 10, 1940	Unchanged.
5	June 6, 1934	The cervical, thoracic, and lumbar apophyseal joints have rarefied articular processes, narrow joint spaces, and ragged facets. All vertebral bodies rarefied. Ligaments normal except for slight ossification of long. lig. at the level of L II–III. Sacroiliac, costovertebral, and hip joints have narrowed spaces and blurred outlines.
	Dec. 10, 1936	The thoracic apophyseal joints are now ankylosed. The appearances of the cervical and lumbar apophyseal joints have not changed, except for a definite decrease of rarefaction of the articular processes. All the lig. flava are ossified. Longit. lig. unchanged. Sacroiliacs ankylosed. Costovertebral and hip joints unchanged.
	June 6, 1939	Essentially unchanged, except for increased ossification of the lig. flava. Both the vertebral bodies and the articular processes have regained normal density. Moderate increase of ossification of the lumbar longit. lig.
6	Apr. 3, 1939	Lumbar apophyseal joints have rough facets and narrow joint spaces. Thoracic and cervical segments not properly examined. Sacroiliacs normal. Ligaments normal.

TABLE IV—*Continued*

Case	Date	Observations
	Mar. 29, 1940	(After roentgen therapy.) Lumbar facets smoother, joint spaces apparently wider. Sacroiliacs scalloped. Thoracic apophyseal joints ankylosed, with ossification of long. lig. Hip joints involved (Fig. 9).
	Oct. 29, 1940	Beginning ankylosis of hip joints. Complete ankylosis of sacroiliacs. Otherwise unchanged.
7	Feb. 6, 1940	The cervical and lumbar apophyseal joints have rarefied articular processes, narrow joint spaces, and rough facets. Vertebral bodies and ligaments normal. Sacroiliac and hip joints have scalloped outlines. Thoracic spine normal.
	Apr. 4, 1940	The lumbar facets have become eburnated. Otherwise no change.
	Feb. 27, 1941	The cervical apophyseal joints are now ankylosed, and the cervical lig. flava and long. lig. are ossified. Otherwise no change.
8	Dec. 18, 1939	The 4th lumbar apophyseal joint only is involved: its articular processes are so strongly rarefied as to be almost indistinguishable, and the joint space is covered by a hazy shadow (Fig. 3).
	Feb. 2, 1940	(After roentgen therapy.) The involved 4th lumbar apophyseal joint is now normal.
	Apr. 6, 1940	Unchanged. Nothing pathological.
	Feb. 27, 1941	Unchanged. Nothing pathological.
9	Nov. 6, 1939	Lumbar and thoracic apophyseal joints ankylosed. Lumbar vertebral bodies moderately rarefied. Thoracic lig. flava and long. lig. ossified; the other ligaments normal. Sacroiliacs ankylosed.
	Feb. 23, 1940	The lumbar vertebral bodies have regained normal density. Otherwise no change.
10	Dec. 29, 1939	The 2nd lumbar apophyseal joint has ragged facets and a narrow joint space. The sacroiliac articular surfaces are eburnated and scalloped. Ligaments normal.
	Mar. 11, 1940	The ragged facets of the 2nd lumbar apophyseal joint have become eburnated. Otherwise no change.
11	June 23, 1939	All the apophyseal joints have narrowed joint spaces; the lumbar apophyseal joints have rough facets. The lumbar and cervical lig. flava are ossified. Sacroiliacs almost ankylosed. Hip joints blurred.
	Feb. 19, 1941	The thoracic and cervical apophyseal joints are almost ankylosed. The lumbar facets have become eburnated. The long. lig. and all the lig. flava are now ossified. Sacroiliacs and hip joints unchanged.
12	May 18, 1936	Arthritis of both hands. The 2nd and 3rd cervical apophyseal joints have ragged facets and narrow joint spaces. Spine otherwise normal. Hip and sacroiliac joints normal.
	Apr. 2, 1939	Ankylosis of 2nd, 3rd, and 4th cervical apophyseal joints, with ossification of lig. flava at this level. Otherwise no change.

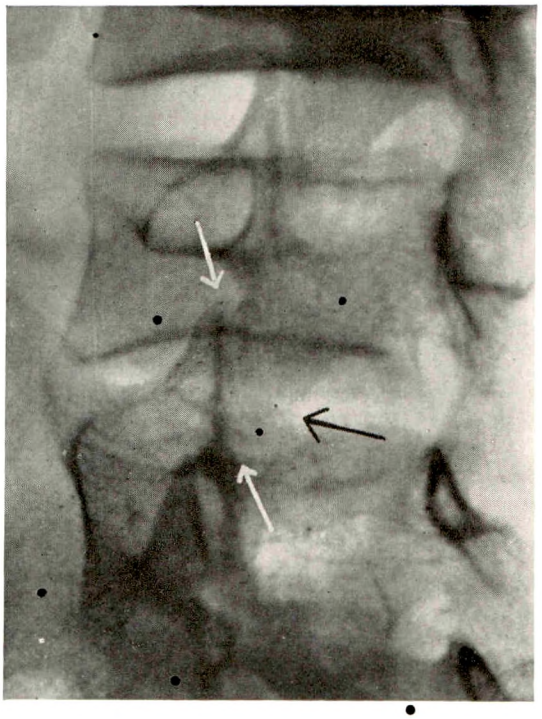


Fig. 4. Case 4. Stage I. Rarefaction of 4th lumbar articular processes (black arrow), outlines of joint space blurred (white arrows). Compare with normal subjacent joint. The superjacent joint shows slight roughening of the articular surfaces (facets), corresponding to an early phase of Stage II.

dence of disease. Hence involvement of the apophyseal joints is considered here the essential lesion associated with the type of rigidity under discussion.

This observation is not new. In the classical papers ankylosis of the apophyseal joints was recorded in all the cases of vertebral stiffness in which autopsy was made (Table III); but the finding was not regarded as significant.[2,3,12,14] Soon after Marie's first and Strümpell's second article had been published, Sivén[25] and Fraenkel[5] reported arthritis of the apophyseal joints as the main lesion in cases of rhizomelic spondylosis. The presence of some more salient anatomic change, such as softening of bone or ossification of ligaments, together with the peculiar localization in spine and hips, seems to have led most other workers to discount the constant but less spectacular lesion of the apophyseal joints. Since the alterations in other vertebral parts are neither constant nor, if present, always of the same kind, interpretations became conflicting. Present concepts, including Lawford Knaggs' accepted view,[9,20] are still based upon the theories which were offered by early investigators on account of only two postmortem records.[3,15]

The data classified in Tables II and IV suggest that there are three fairly distinct stages in the development of the lesion.

Stage I. Early phase. The main sign is stippled or diffuse rarefaction of articular processes, ranging from slight loss of the

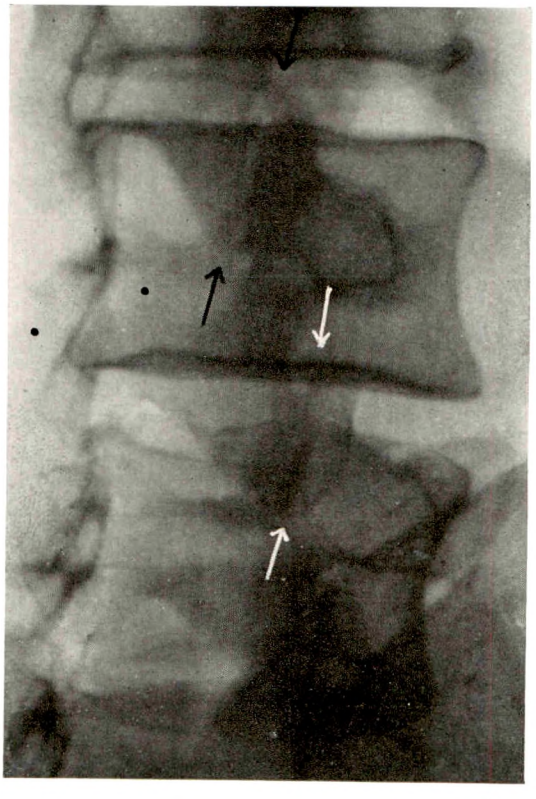


Fig. 5. Case 14. Stage II. Rarefaction of articular processes with severe narrowing of the joint space in the 4th lumbar apophyseal articulation (white arrows). Narrowing of the joint space with ragged and condensed facets in the superjacent joint (black arrows). The findings show that the appearances may vary from joint to joint even in the same vertebral section, hypertrophic reactions being sometimes superadded to an originally atrophic arthritis.

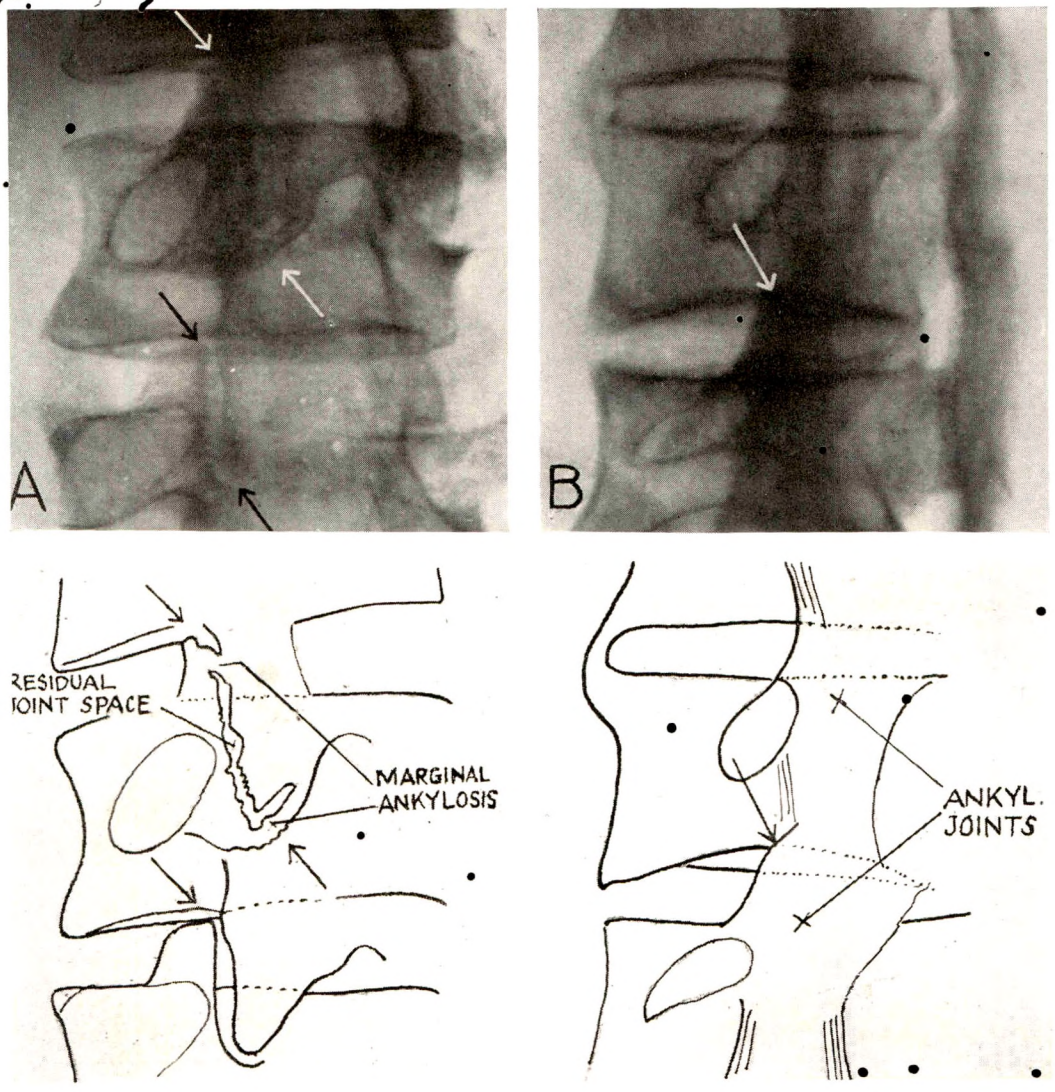


FIG. 6. Difference between circling and complete ankylosis. *A*, circling ankylosis of 3rd lumbar apophyseal joint (white arrows): the joint space is still preserved in its central parts, bony bridging being confined to the marginal regions. Compare with normal subjacent joint (black arrows). *B*, complete bony ankylosis (arrow). See the text.

density to almost complete dissolution of the structure of the bone. The facets of the involved articular processes have indistinct outlines. The intervening joint space is slightly narrowed and sometimes clouded. There is no rarefaction of the vertebral bodies, and no ossification of ligaments. In one case (Fig. 3) the involved parts resumed normal appearances after treatment, and the clinical symptoms subsided completely. This seems to indicate that the morbid reaction is reversible at this stage.

Stage II. Moderately advanced phase. The main sign is erosion, roughness, or scalloping of the facets, and definite narrowing of the joint space between them. Often, but not always, the corresponding articular processes are increased in density and the vertebral bodies rarefied. This contrasting coexistence of rarefaction in one part with increased bone density in another part of the same vertebra is almost characteristic of Stage II. Small osteophytes are sometimes present at the edges of the

facets. At the level of the involved segments slight or incomplete ossification of the ligaments may be visible. Although occasionally some of these changes become less definite after treatment (Fig. 9), there is no conclusive evidence to show that the condition is still reversible at Stage II. But the appearances may remain unchanged for many years, showing that the lesion may become arrested at Stage II at least for a long period. In other cases the disease progresses more or less rapidly towards Stage III.

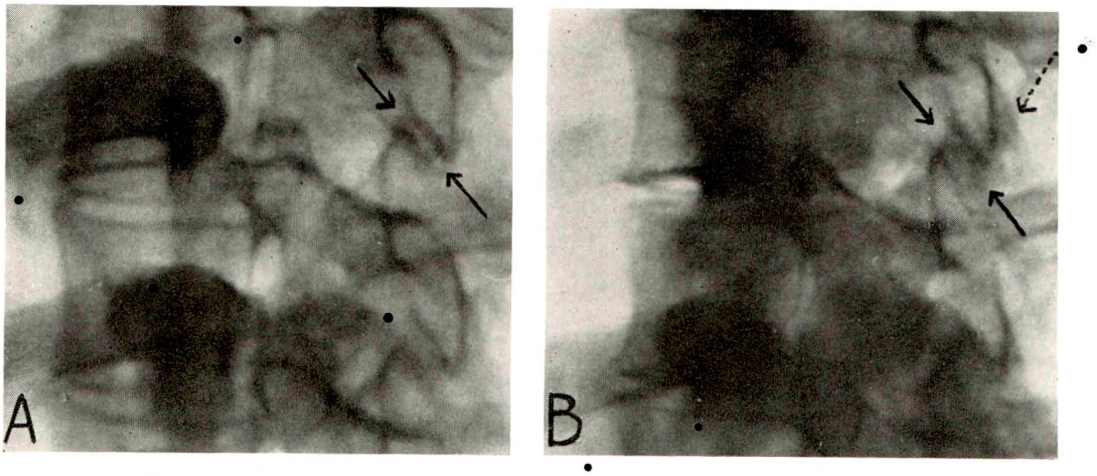


FIG. 7. Case 45. Stage III. Thoracic spine. Development of ankylosis. *A*, joint space clearly outlined, facets and articular processes normal (arrows). *B*, seven months later, the same joint is ankylosed, the joint space being filled with bony substance (arrows). The ligamentum flavum has become ossified (dotted arrow).

Stage III. Terminal phase. The main sign is ankylosis of the apophyseal joints by means of bony union: either complete, with fusion of contiguous facets and disappearance of the intervening joint space; or marginal, whereby the central part of the joint space remains radiolucent and the bony connection extends along the external or capsular region of the joint (Fig. 6, *A* and *B*). When it occurs in peripheral joints, this marginal ankylosis is sometimes named *ankylose cerclée* (circling ankylosis) in French publications.[13] Rarefaction of vertebral bodies, if present, is usually less definite than at Stage II; in fact, vertebral bodies which were found rarefied at Stage II may regain normal density at Stage III.[16] Ossification of ligaments may be absent at Stage III (Fig. 8); if present, it usually is strongly marked and extensive.

The findings also show that the lesion is confined to one or a small number of apophyseal joints at Stage I; at Stages II and III it may be either systemic or localized. Except at very late stages, when virtually all the apophyseal joints are ankylosed, the involved articulations are not all affected in the same degree: complete bony ankylosis in one joint may coexist with an incipient lesion of other joints, and several stages may be present simultaneously in the same person, and even in the same vertebral region (Fig. 4, 5 and 8).

The periods during which the lesion progresses from Stage I to Stage II or III differ considerably from case to case (Table V). Stage III may be reached within one year; but the disease may also become arrested at Stage II for over twenty-five years. During the period extending from three to about thirty years after the onset of symptoms, the number of cases of Stage II is approximately equal to the number of cases of Stage III. This fact is of some diagnostic importance, since at Stage II the lesion is usually confined to, or most

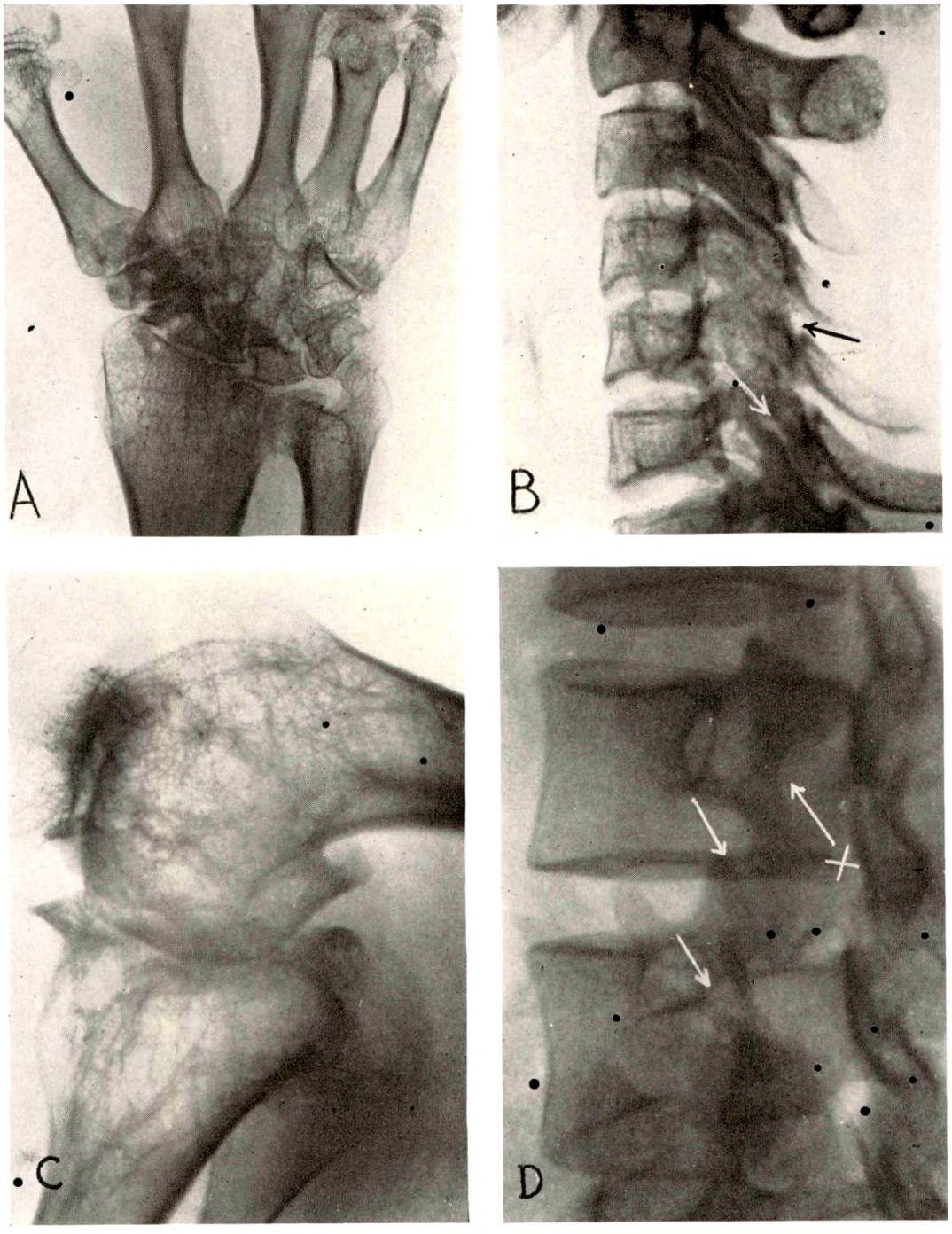


Fig. 8. Case 48. Almost all of the synovial joints of the body were involved. *A*, narrowing of joint spaces of wrist, with partial ankylosis, rarefaction of bones, but also some moderate condensation on radial side. *B*, some of the cervical apophyseal joints are ankylosed (black arrow), others show narrowed joint spaces with ragged and condensed facets (white arrow). Rarefaction of articular processes. *C*, knee ankylosed in flexed position, articular bone rarefied, but also some marginal overgrowth. *D*, the 4th and 5th lumbar apophyseal joints are ankylosed (arrows), while the 3rd has a very narrow joint space with ragged and condensed facets (arrow at ×). Lesion strictly confined to the apophyseal joints; the vertebral bodies, discs and ligaments are not involved. Clinically, a typical instance of Strümpell-Marie disease. Note that the lesions of the apophyseal joints are identical in type with those of the peripheral articulations.

TABLE V

RELATION BETWEEN STAGES AND DURATION OF SYMPTOMS

	Less than 1 yr.	1–2 yr.	3–4 yr.	5–6 yr.	7–8 yr.	9–10 yr.	11–12 yr.	13–14 yr.	15–16 yr.	17–18 yr.	19–20 yr.	Over 20 yr.	Total Number of Cases
Stage I	4	1											5
Stage II	1	5	3	5	3	4	1	1				1	24
Stage III	1	3	5	3		4		3	1			1	21

definite in, the apophyseal joints. Ossification of ligaments, which is often considered a diagnostic criterion, is not conspicuous at Stage II, if present at all. Since a lesion of the apophyseal joints is not always demonstrable by the conventional roentgenographic technique,[6,16] a number of cases may have escaped recognition, or may have been grouped with "entities" to which they do not belong in reality. I recovered among my own records 8 such cases which I had previously labelled fibrositis, vertebral rarefaction, or obscure rheumatic disease.

VI. ACCOMPANYING LESIONS OF THE VERTEBRAE AND PELVIS

A. Rarefaction of Vertebral Bodies. This is distinct from the rarefaction which is confined to the articular processes during Stage I. The vertebral bodies were found to be rarefied in 26 cases (52 per cent). This rarefaction was absent in all the cases of Stage I, but present in 75 per cent of the cases of Stage II and in 25 per cent of the cases of Stage III. This decreasing frequency of rarefaction at Stage III is in accord with the observation showing that the vertebral bodies tend to regain normal density when bony ankylosis of the apophyseal joints has taken place.[16] For example, in Case 26, Table II (No. 5 of Table IV), the vertebral bodies were strongly rarefied in June, 1934; but their density was normal again in December, 1936, and was still normal in June, 1939, when ankylosis of the apophyseal joints was found to be complete.

These observations show that rarefaction of vertebral bodies, being neither a constant nor an early sign of Strümpell-Marie disease, cannot be considered pathognomonic.

B. Ossification of vertebral ligaments, which is easily demonstrable on roentgenograms made in the tangential projection, is not always visible in routine views.[19] Ossification of the longitudinal and interspinous ligaments was analyzed on lateral

TABLE VI

OSSIFICATION OF VERTEBRAL LIGAMENTS

	Stage I	Stage II	Stage III	Total
Flava alone	—	2	4	6
Flava and longitudinal	—	1	6	7
Flava, longitudinal and interspinous	—	3	5	8
Longitudinal alone	—	5	3	8
Longitudinal and interspinous	—	2	—	2
Interspinous alone	—	—	—	0
Flava and interspinous	—	1	2	3
Total	0	14 = 58% of cases of stage II	20 = 95% of cases of stage III	34 = 68% of all cases

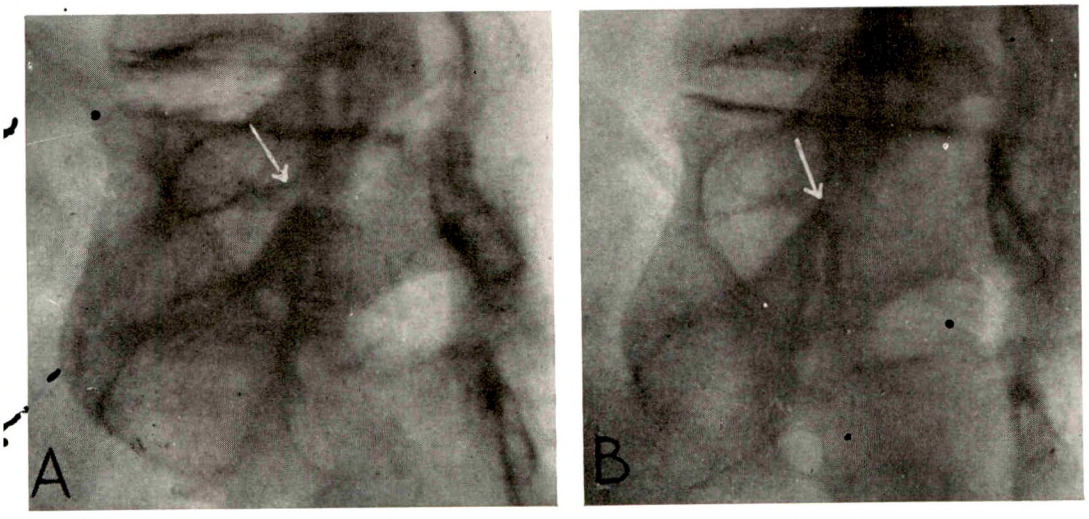


FIG. 9. Case 45. Result of roentgen therapy. Lumbosacral junction. *A*, rarefaction of superjacent articular process of 5th lumbar apophyseal joint; facets blurred; joint space almost invisible. *B*, two months later, after termination of roentgen treatment, rarefaction is no longer definite, normal bone density being regained; the joint space has become visible rather clearly. The patient, bedridden when treatment was begun, resumed his normal occupation two weeks after its termination and has remained free of symptoms for over a year since.

views; of the ligamenta flava, on oblique views; and of the lateral fibers of the anterior longitudinal ligament, on antero-posterior views. Table VI shows that ossification was present in none of the cases of Stage I, in one-half of the cases of Stage II, and in a majority of cases of Stage III. The ligaments close to the neural arch and apophyseal joints were found to be ossified more frequently and more markedly than those of the more ventral parts. The correlation between the degree of ossification and the three stages of the apophyseal lesion was analyzed on roentgenograms of the anterior longitudinal ligaments which can be studied more accurately than the less accessible ligaments of the posterior parts of the spine. In Table VII, "grade A" implies the presence of small thorn-like ossifications at the edges of the vertebral bodies, resembling osteophytes but for their smaller size and lesser density. "Grade B" means additional patchy and incomplete ossification extending further across the intervertebral space. "Grade C" signifies complete bridging of this space. No ossification was present at Stage I; there was a fairly uniform distribution of the three grades at Stage II; and grade C was predominant at Stage III. It should be noted

TABLE VII

OSSIFICATION OF LONGITUDINAL LIGAMENTS

	Stage I	Stage II	Stage III	Total
Grade A	—	3	—	3
Grade B	—	5	1	6
Grade C	—	4	12	16
Total	0	12 = 50% of cases of stage II	13 = 61% of cases of stage III	25 = 50% of all all cases

that this correlation between the degree of ossification and the stages of the lesion was entirely independent of the duration of the disease. This is perhaps not surprising, as the degree of the changes in the apophyseal joints also does not depend on the time factor.

The data, in conjunction with those presented in Table IV, indicate that ossification of ligaments begins to appear when the disease is moderately advanced. Ossification of ligaments lags behind the development of the apophyseal joint lesion and is not a constant finding. This does not support the view that the clinical syndrome of Strümpell-Marie disease is caused by a systemic ossification of ligaments. In one-third of our patients of this group, no ossification could be demonstrated in the different vertebral ligaments.

TABLE VIII

INCIDENCE OF SARCROILIAC INVOLVEMENT

	Stage I	Stage II	Stage III
Grade A	3	—	—
Grade B	—	11	7
Grade C	—	12	10
Total	3 = 60%	23 = 96%	17 = 81%

C. Involvement of the sacroiliac joints, ranging from blurring of the joint outlines to complete bony ankylosis, was present in 43 instances (86 per cent). In the remaining 7 patients (14 per cent) the sacroiliac joints were normal both on clinical examination and roentgenologically; in these cases, the apophyseal joint lesion was confined to the thoracic or cervical vertebrae. In Table VIII, in which the roentgenographic findings are grouped according to their degree and in conjunction with the three stages of the disease, "grade A" implies blurring of the sacroiliac articular outlines; "grade B," scalloping of the articular surfaces with or without eburnation of the adjacent bone; "grade C," complete or almost complete bony ankylosis. The data of Table VIII show that the incidence of sacroiliac involvement increases as the lesion of the apophyseal joints evolves towards Stage III. But the severity of the sacroiliac lesion is not proportional to the severity of the apophyseal lesion. Ankylosis of the sacroiliac joints may either precede or follow ankylosis of the apophyseal joints. For example, in Case 45 (No. 6 of Table IV), the sacroiliac joints were still normal when the apophyseal joints were already completely ankylosed; but one year later the sacroiliac articular surfaces became ragged, and this appearance did not change during the subsequent six months.

Since great diagnostic importance is usually given to the sacroiliac lesion, the following inferences from the above findings may have some significance: (1) the sacroiliac joints are not involved in every case, especially not when the disease begins in, or remains confined to, the cervical or thoracic segments; (2) even when the lumbar and lumbosacral apophyseal joints are involved, the sacroiliac joints may remain normal for periods of years. An early diagnosis cannot be based, therefore, upon the presence or absence of sacroiliac lesions. Their presence merely supports the diagnosis of Strümpell-Marie disease, but their absence does not disprove it.

D. Involvement of the Costovertebral Joints. Diminished respiratory expansion of the chest, suggestive of involvement of the costovertebral joints, was noted in 31 cases (62 per cent), all of them at Stages II and III. In 15 of these patients, roentgenograms showed roughening, eburnation, or ankylosis of these articulations. Owing to the great technical difficulties encountered in obtaining adequate roentgenograms of these joints, the data could not be analyzed further.

E. Involvement of the vertebral symphyses, shown by alterations of the intervertebral spaces and horizontal vertebral surfaces, was not demonstrable in this series of cases. It is true that fragmentation of the vertebral disc cannot be shown on roentgeno-

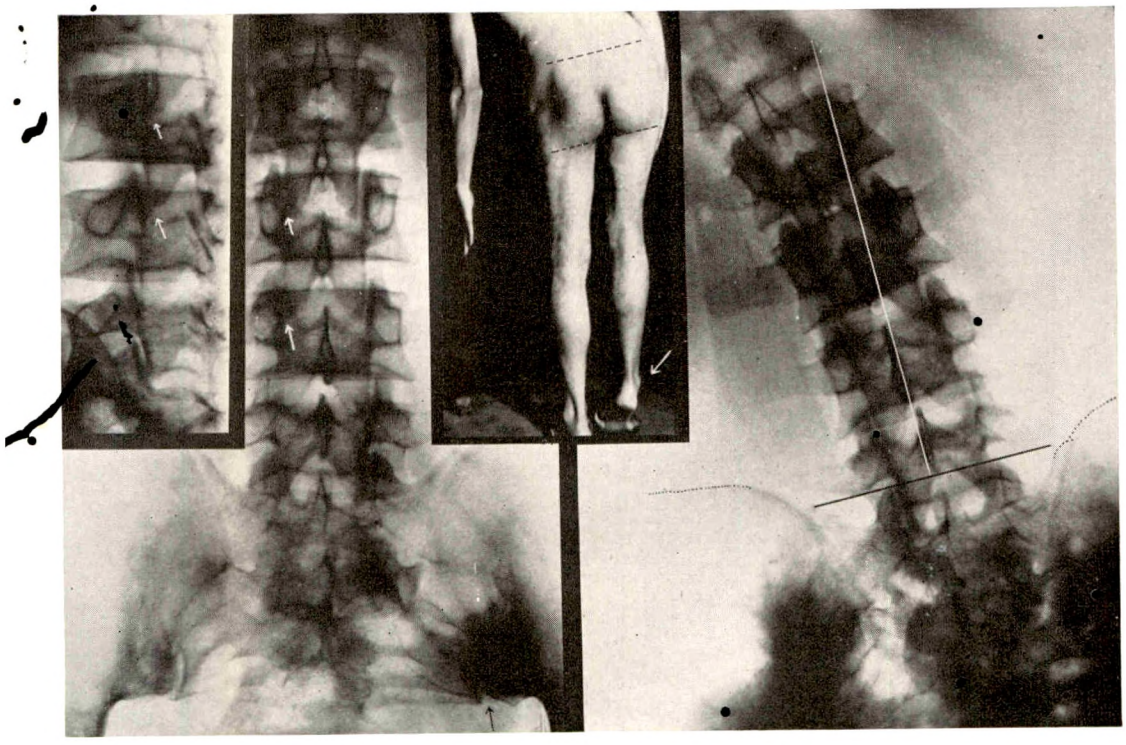


Fig. 10. Case 2. Stage 1. The left 3rd and 4th lumbar apophyseal joints have blurred facets and narrow joint spaces (white arrows on insert left); the sacroiliac joints are involved (black arrow). Insert in center shows maximum amount of sidewards bending of which the patient is capable: most of this motion is achieved by means of lifting of the pelvis and foot (arrow) on the side of the convexity. The patient was not conscious of making these auxiliary movements. Roentgenogram taken during sidewards bending (upright position, 4 ft.) reveals slight flexion of upper lumbar spine; the movement of the pelvis is indicated by the black line drawn parallel to the upper horizontal surface of the 1st sacral vertebra; the 3rd, 4th, and 5th lumbar segments are almost completely rigid.

grams at early stages; but it leads to narrowing of the corresponding interspace within less than one year in most cases, and slight irregularities or eburnation of the vertebral surfaces become visible not much later, as a rule. The absence of such changes in patients whose vertebral symptoms had persisted for ten years or more virtually excludes a lesion of vertebral symphyses in these cases. In 2 patients with Strümpell-Marie disease not included in this report, several intervertebral spaces were found to be narrowed in segments distant from the vertebrae involved by apophyseal joint lesions; this was interpreted as an accidental coexistence of two distinct lesions.

F. Involvement of the Pubic Symphysis. I have observed complete ossification of the pubic symphysis in 2 or 3 cases of Strümpell-Marie disease not recorded here; but in the present series, the pubic symphyses appeared to be normal. In one case, the symphysis seemed to be bridged by what appeared to be an ossified ligament.

In 3 cases irregular bony spikes, suggestive of ossification of muscles or tendons, projected from the inferior margins of the pubic and ischial bones. Rarefaction of the pubic bones was noted in 7 cases (14 per cent) in the simultaneous presence of rarefaction of vertebral bodies.

VII. Involvement of Other Joints

Limitation of movements and pain in one shoulder or both was a common symptom (42 cases: 84 per cent). The roentgen findings were negative except for 2 cases with complete ankylosis of almost all the

joints of the body. I found it difficult to ascertain whether the symptoms were caused by arthritis, muscle spasm, or radicular neuritis.

In 24 cases, pain and limited mobility were present in the hip joints (48 per cent); in 16 of these, roentgenograms disclosed lesions of these joints ranging from blurring of the articular outlines to almost complete ankylosis.

Peripheral joints—fingers, toes, wrists, ankles, elbows, or knees—were found to be involved both clinically and roentgenologically in 9 instances (18 per cent). In 4 other patients there was pain, sometimes with some swelling, in peripheral joints in the absence of definite evidence of arthritis. These patients had signs of radicular neuritis, and the articular symptoms may have been due to radicular manifestations, since early stages of neurotrophic lesions cannot always be distinguished from arthritis.[18]

VIII. COMMENTS

The roentgen analysis of the lesions under discussion involves many sources of error. There is, first, the fundamental limitation in the roentgenologic interpretation of arthritis: the key structures, cartilage and synovial membrane, cannot be seen on roentgenograms except by the use of auxiliary methods which are impracticable in the inaccessible apophyseal joints. Lesions of cartilage and synovial membranes are recognized by inference rather than by direct evidence, e.g., from the width of the joint space, or from erosion of the bony articular surfaces. Second, technical factors add to this basic difficulty. The curved planes of the facets may overlap, especially in the lumbar spine, thereby obscuring the joint space. In the thoracic segments adjacent bones often overshadow the articular processes. Like other compact bones, the articular processes do not easily undergo rarefaction; and rarefaction may not always become visible on roentgenograms. Variations of density in the articular processes are difficult to evaluate; differences in size, position, and amount of cortical bone often cause normal articular processes of the same vertebra to be of different density. Densitometry is not applicable, as the density of intervening viscera and of their contents is subject to excessive variations; and superimposition of intestinal gas upon a lumbar articular process, or of a bronchial lumen upon a thoracic facet, may produce appearances falsely indicative of rarefaction. On roentgenograms, thickening of the joint capsule, which is easily demonstrable for the peripheral joints, is visible only exceptionally in the apophyseal joints.[16] Finally, since early and active stages of arthritis are not often accessible to anatomic study, the roentgen interpretation of these lesions is not yet based on firm ground.

For all these reasons the results of roentgen studies of the apophyseal joints must be considered with reserve. The roentgenologic method is imperfect. But the anatomical method also has its limitations. The condition seen at autopsy of many vertebral lesions is essentially a scar. The morbid process which produced the scar cannot be recognized directly, but only by inference and analogy. Consequently, direct observation of the development of a vertebral lesion had to be attempted, even though with the method used the results could not be complete. Together with the complete but indirect anatomical evidence, the incomplete but direct roentgenologic evidence has its value. This is pointed out here because the inferences drawn from roentgen examinations made during life do not always tally with the conceptions reached by the purely anatomical approach.

IX. CLINICAL FINDINGS

Laboratory findings in this series are not sufficiently complete to allow statistical analysis. The results of physical examinations are grouped in Table IX and Figure 11 with the three stages and with the condition of the apophyseal joints, vertebral bodies, and ligaments.

There were three main clinical manifestations in this series: (1) stiffness of the

back and/or neck; (2) pain and/or tenderness of the back and/or neck; (3) signs or symptoms of radicular neuritis. In Table IX and Figure 11 "rigidity" means severe limitation of vertebral movements, with a range of lateral lumbar flexion not exceeding 5 degrees, other motions being restricted proportionally. "Local pain" implies spontaneous pain in the neck and/or back, usually associated with tenderness on pressure upon the spine about 1 inch to the left or right of the spinous processes. "Radiculitis" or "radicular manifestations" signifies frank radicular neuritis; pain radiating to the flanks or limbs in other than segmental distribution was not included, although it may be due to involvement of nerve roots in certain cases, since slight or incipient radicular neuritis cannot always be distinguished from referred pain.[17,18]

The tabulated findings show that rigidity was associated with lesions of the apophyseal joints in 100 per cent of the cases, regardless of the severity and extent of these lesions: patients with an incipient or slight lesion confined to one single apophyseal joint were found to be as stiff as patients

TABLE IX

RELATION BETWEEN LESIONS AND SYMPTOMS

	Apophyseal Joints Involved in the Absence of		
	Rarefaction of vertebral bodies	Ossified ligaments	Both rarefaction and ossification
Local pain	15 = 62.5%	16 = 95%	7 = 87.5%
Radicular symptoms	4 = 16.6%	5 = 29%	3 = 37.6%
Rigidity	24 = 100%	17 = 100%	8 = 100%

with bony ankylosis of most of the apophyseal joints (Fig. 3). This rigidity was present in the absence of rarefaction of vertebral bodies, of ossification of ligaments, and of other changes not involving the apophyseal joints. It has been shown that extensive ossification of vertebral ligaments need not interfere with normal vertebral movements.[19] Although in biologic sciences a correlation of 100 per cent, which means a correlation coefficient of 1.0, is rightly considered to be too good to be true, the above findings seem to prove that the

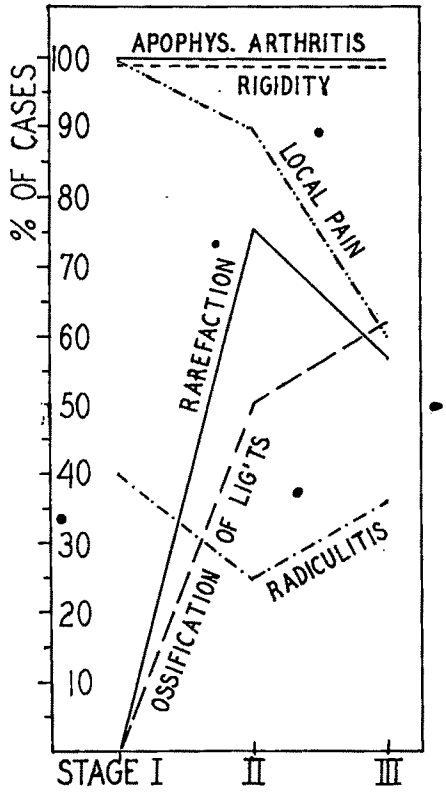


FIG. 11. Graph showing the clinical findings observed during the three stages, and the correlation of the apophyseal joint lesion with both rarefaction and ossification of ligaments. See the text.

stiffness of back or neck present in Strümpell-Marie disease is a direct and constant result of the apophyseal joint lesion under discussion.

Local pain, a constant symptom at Stage 1, was less frequent at Stage II, and again less common at Stage III. This is in accord with the classical descriptions which mention that pain subsides as the disease progresses. Local pain was independent of the condition of the vertebral bodies and ligaments in our series; like rigidity, it seemed to be caused by the lesion of the apophyseal joints alone.

Radicular neuritis was noted in about

one-third of all cases; its incidence was highest at Stage II and lowest at Stage III.

In Table X the clinical manifestations are grouped in conjunction with the roentgenologic appearances of the apophyseal joints, considered according to the condition of the articular processes, their facets, and joint spaces. Rigidity was present whenever one of these parts was involved. Local pain was constant in the presence of rarefied articular processes and/or of eroded facets, but comparatively rare in the presence of ankylosis. The incidence of radicular manifestations was highest in the presence of ankylosis. This analysis does not add much to the results obtained from the data of Table IX.

TABLE X

RELATION BETWEEN LESIONS AND SYMPTOMS

	Local Pain	Radicular Manifestations	Rigidity
Articular processes rarefied	22 = 100%	6 = 27%	22 = 100%
Facets ragged	24 = 100%	5 = 20.8%	24 = 100%
Apophyseal joints ankylosed	14 = 70%	8 = 38%	21 = 100%

Persistent contraction of muscles was noted in many patients, but was not tabulated since I did not know of an objective diagnostic test. On palpation, the muscles involved, usually the hamstring group and the stretchers of the lower back, gave the impression of being thinner, harder, and less pliable than normal. In 47 patients (94 per cent) of both sexes, of different ages, and at different stages of the disease, a striking loss of the activity of the facial muscles was observed. This produced an inert or vacant expression which contrasted strongly with the lively facial activity commonly exhibited by Near East people. The absence of this play of expressions in our patients was therefore more conspicuous perhaps than in instances observed in other countries where persons are more reluctant to show their feelings. Except for a casual reference made by Marie in his first paper, this rigidity of the face has not been recorded in the publications available to me. One may speculate whether it is due to a reflex inhibition, a part of the general attempt to avoid bodily movements since these elicit pain; or whether it is caused by a systemic disease of the musculature. There seems to be no method by which this question could be investigated at present.

XI. THE PROBLEM OF THE STIFF BACK

The questions relating to normal and limited mobility of the back and neck are complex and have many side issues; it is not possible here to discuss them at length. Some of the aspects of the problem are presented separately. In connection with the subject under review, three points are of interest: (1) the movements of the back and neck in the presence of lesions of the vertebral symphyses; (2) the movements of the back and neck in the presence of lesions of the apophyseal joints; (3) stiffness of the back or neck caused by lesions other than vertebral.

(1) Of 50 patients with thinned intervertebral discs, with or without osteophytes at the vertebral edges, but *with normal apophyseal joints*, 48 (96 per cent) were not conscious of a limitation of the involved spinal area, nor did physical examination reveal limited movements. Photographs sometimes disclosed a moderate flattening of the spinal curves during sidewards flexion. Measurements made on roentgenograms showed normal ranges of motion in 39 cases (78 per cent); a slight limitation, in 8 patients (16 per cent); and definite limitation, in the remaining 3 patients (6 per cent). When present, limitation of movements was confined to the segments with thinned discs, adjacent segments showing either normal or moderately increased mobility. Consequently, the *total* movement intended could be achieved by means of increased mobility of the neighboring vertebrae. This seems to account for the fact that the patients were not conscious of

a limitation of the movements of the involved pairs of vertebrae. These results confirm findings previously reported.[16,18,19]

(2) Of 20 patients with lesions suggestive of hypertrophic (osteo-) arthritis of the apophyseal joints, such as eburnation of the facets, moderate narrowing of the joint space, osteophytes at the articular margins, 14 (70 per cent) complained of moderate stiffness in the involved region, and mobility was found to be diminished on roentgenographic records. In patients with findings indicative of rheumatoid arthritis of the apophyseal joints, as shown by rarefied articular processes, blurred facets, and narrowed joint spaces, we noted stiffness of the involved vertebral region, usually associated with severe pain, in 28 out of 30 cases (93 per cent). In contrast to the patients with lesions of the vertebral symphyses, the movements of the vertebrae involved and of at least one superjacent pair of vertebrae were found to be definitely limited on roentgenograms. In most of these cases, physical examination revealed stiffness of the entire spinal section in which the apophyseal arthritis was localized, regardless of the number of apophyseal joints involved. For example, atrophic arthritis of a single lumbar apophyseal joint caused the whole lumbar spine to be immovable both actively and passively (Fig. 3).

(3) Limitation of vertebral movements was observed to occur in the presence of renal calculi, paranephric abscess, gallbladder disease, furuncles of the neck or back, in the absence of demonstrable vertebral abnormalities. Usually, flexion was free towards the side of the diseased viscus, but limited towards the opposite side. Only 5 out of 28 patients of this group were conscious of the limitation of motion. In persons suffering from "lumbago," active movements were strongly restricted, but almost the full range of motion could usually be achieved by gentle passive bending and extending.

This brief summary of observations on vertebral movements may be sufficient to show that limitation of the movements of back and neck, as experienced by the patient and demonstrable on roentgenograms, is almost constantly present when the apophyseal joints are involved, but is either slight, unnoticed, or absent when only the vertebral symphyses are diseased.

XII. THE PROBLEM OF PAIN OF VERTEBRAL ORIGIN

In recent years, pain in the lower back has been ascribed to a variety of abnormalities in the lumbar and lumbosacral vertebrae. In a series of 100 cases of backache, different lesions and abnormalities of the lumbar vertebrae were noted in 82 instances. A control series of 100 cases showed, however, that similar lesions and abnormalities were present in 61 persons in the absence of symptoms. It is difficult to understand why the same lesion should cause symptoms in one case, but be unnoticed by other patients. Age, habits, posture, muscular coordination, and mental factors are perhaps responsible for the discrepancy; and reflex pain due to some unrecognized lesion of pelvic or abdominal viscera may come into play.

These limitations do not apply in the same measure to the question of pain in the neck. Static and postural factors play a less important part, reflex pain is relatively rare, and mental influences do not seem to affect the neck as commonly as the lower back. Hence the problem of vertebral pain was studied on patients with lesions of the cervical vertebrae. Of 19 patients with lesions of the cervical apophyseal joints, 18 complained of constant or recurrent pain in the neck; but only 3 out of 60 patients with lesions confined to the vertebral symphyses felt pain in the cervical region.

Segmental neuritis is caused by lesions of the vertebral symphyses in a large number of cases.[17,18] In a series of 100 instances of flattening of cervical intervertebral discs, symptoms of radicular neuritis were noted in 82 persons; only 2 of these complained of pain in the neck; the others were not conscious of any discomfort localized in the

neck. Lesions of the apophyseal joints, while causing pain in the neck in most instances, do not seem to induce radicular neuritis in many cases: in only 6 out of 19 patients with lesions of the cervical apophyseal joints were symptoms of segmental neuritis noted. I have been quoted erroneously as having stated that arthritis of the apophyseal joints (spondylarthritis) is the most common cause of radicular neuritis of vertebral origin; but I have pointed out[16,19] that compression of the nerve root depends on the spatial relations between the caliber of the root, the original width of the neural foramen, and the amount of constriction of the foramen. In segments in which the nerve is slender and the foramen wide, such as the thoracic spine, narrowing of the foramen need not cause the roots to be encroached on; but where the nerve is thick and the foramen relatively narrow, as in the cervical region, a slight constriction of the foramen is often sufficient to produce pressure upon the root. In general, the amount of narrowing of the foramen that is caused by flattening of the corresponding disc is definitely greater than the constriction caused by lesions of the apophyseal joint. This, together with the greater incidence of lesions of the discs, makes flattening of the discs the most common cause of radicular neuritis, although, according to the foregoing discussion, compression of nerve roots may occur in many other vertebral diseases.

The observations seem to show that pain in the neck is a common symptom of lesions of the cervical apophyseal joints, but rare in the presence of lesions of the cervical vertebral symphyses. On the other hand, radicular neuritis is more frequently caused by lesions of the discs than by lesions of the apophyseal joints.

XIV. DISCUSSION

The roentgen findings above recorded indicate that the lesion which is associated with the clinical manifestations of Strümpell-Marie disease is localized in the apophyseal joints. Rarefaction of articular processes with narrowing of the intervening space is present at incipient and early stages. The lesion may then evolve rapidly towards complete or circling bony ankylosis; or it may take a slower course and become arrested at intervals, during which the articular surfaces may become rough and eburnated. Ankylosis in one joint may coexist with eburnation in another joint, or the two may occur simultaneously in different parts of the same joint. This would seem to indicate that the two morphologic characters, viz., ankylosis and eburnation, correspond merely to different phases of the same morbid condition.

These appearances, and the sequence of events, are typical of rheumatoid (atrophic) arthritis. Rheumatoid arthritis is potentially always an ankylosing lesion. But marginal osteophytes and eburnation, which are usually considered characteristic of osteoarthritis (hypertrophic arthritis, degenerative joint disease), may occur at quiescent or arrested stages of rheumatoid arthritis of peripheral joints. The anatomic appearances are then ambiguous even histologically.[10] The data above recorded show that, as in other joints, rheumatoid arthritis of the apophyseal joints need not cause ankylosis in every case. I have previously adopted Fraenkel's term, ankylopoietic spondylarthritis, to designate the lesion under review. But since ankylosis is only the potential result of rheumatoid arthritis, and since the observations show that the ankylosing is actually continuous with the rheumatoid form, I now believe that a distinction between ankylopoietic and rheumatoid spondylarthritis can no longer be made.

In the presence of rheumatoid arthritis of peripheral joints, the adjacent bone may become rarefied. The amount of rarefaction is usually proportional to the activity and duration of the articular lesion. The rarefaction of vertebral bodies which is present at moderately advanced stages of atrophic spondylarthritis would seem to correspond to this para-articular rarefaction of other bones. Hyperemia[13] and proliferation of

granulation tissue[20] are held to account for this rarefaction. Owing to their cancellous structure and their abundant venous sinuses,[27] the vertebral bodies undergo rarefaction readily. It is believed[13] that the lime salts set free by rarefaction can be deposited in adjacent connective tissue if this has become de-differentiated as a result of the complex reactions which are usually called inflammation. Callus, for instance, is formed in this manner at least in many cases. The ligaments of the spine, which are the only connective tissue close to the vertebrae, may take part in the inflammation of the apophyseal joints and may then become ossified when neighboring bone is rarefied and mobility is limited.[19] This view is supported by the finding of a predominance of ossification in the ligaments which surround the apophyseal joints. Further research into the general pathology of connective tissue may alter or amplify this theory; but the fact remains that rarefaction of vertebral bodies and ossification of vertebral ligaments are neither constant nor primary lesions, and that the clinical manifestations of Strümpell-Marie disease cannot be ascribed to either of them. Table XI sums up our observations in an attempt to incorporate the various concepts of the pathology of this disease into the more general view obtained from the findings above recorded.

TABLE XI

SYNOPSIS OF FINDINGS

	Apophyseal Joints	Vertebral Bodies	Vertebral Ligaments	Involvement of Other Joints	Pain		Rigidity	Designations and Synonyms
					Local	Radicular		
Stage I	articular processes rarefied; joint space narrowed	normal	normal	variable	++	±	+	atrophic spondylarthritis
Stage II	joint space narrowed; facets ragged, sometimes eburnated	often rarefied	often in beginning ossification	variable	±	±	+	atrophic spondylarthritis, sometimes with secondary hypertrophic reactions
Stage III	ankylosed	sometimes rarefied, but normal bone density may be regained	often ossified	variable	∓	±	+	if hips and shoulders involved: rhizomelic spondylosis or Strümpell-Marie disease; ankylosing spondylitis if ligaments ossified: spondylitis ossificans ligamentosa if rarefaction present: atrophic spondylitis if ankylosis of apophyseal joints complete: ankylopoietic spondylarthritis—in the German terminology: Bechterew disease

Clinically, two cardinal symptoms of rheumatoid arthritis, pain and limitation of movements, are almost constantly present when the apophyseal joints are involved. The third main sign, swelling of the joint, may also exist, but cannot be recognized because of the inaccessible position of the apophyseal joints. Its presence may be inferred from symptoms of radicular neuritis caused by compression of nerve roots; but, owing to the spatial relations above mentioned, swelling of the apophyseal joint capsule need not produce compression of nerves in every case.

Limitation of vertebral movements was

equally definite at incipient stages of apophyseal-arthritis as in the presence of complete ankylosis of these joints. Control series disclosed that lesions of the vertebral symphyses, which often induce radicular neuritis, cause pain in the spine and limitation of vertebral movements only exceptionally. It has also been shown that ossification of ligaments need not interfere with normal vertebral mobility,[19] and complete rigidity of the spine was present in several patients of this series in the complete absence of ossified ligaments. Hence the findings would seem to show that in the presence of Strümpell-Marie disease, pain and rigidity are caused by the lesion of the apophyseal joints alone.

It has been demonstrated that lesions of the apophyseal joints conform to the anatomic conception of arthritis.[16] Lesions of the vertebral symphyses differ fundamentally from arthritis, since the symphyses are devoid of synovial membranes and free cartilaginous surfaces, in which arthritis, especially rheumatoid arthritis, is localized by definition. Because of the common occurrence of osteophytes, eburnation, or rarefaction, lesions of the vertebral symphyses are usually considered arthritic, but rarefaction and bony overgrowth are uncharacteristic reactions common to a great variety of bone lesions other than arthritic.

The findings in this series suggest that lesions of the apophyseal joints are distinct from lesions of the vertebral symphyses not only anatomically but also in their clinical manifestations. Lesions of the apophyseal joints are associated with pain in the spine and with limitation of vertebral movements. Lesions of the vertebral symphyses do not produce these clinical manifestations. The patient whose radicular neuritis is caused by a lesion of the vertebral symphyses usually refuses to believe that anything is wrong with his spine. The patient who suffers from an arthritis of the apophyseal joints (spondylarthritis) is in no doubt about the seat of the trouble.

XIV. THERAPY

The usual therapeutic measures, such as rest, physiotherapy, administration of gold salts, of the various sulfanilamid compounds, of vitamins, etc., failed to produce any improvement in the patients of this series. Roentgen therapy, advocated by some authors,[8] was given to 17 patients. According to measurements made on specimens, it was estimated that optimal roentgen-ray absorption at the depth of the apophyseal joints could be achieved by using the following factors: 135 to 150 kv., according to the build of the patient; 5 ma.; 0.5 mm. Cu plus 1 mm. Al filtration; target-skin distance of 10 inches (25 cm.); between 18 and 22 r per minute, according to the penetration. After many trials and failures, it was found that individual doses of 40–60 r yield the best therapeutic results. Each individual portal or field, usually 15 by 15 cm. in size, received 40–60 r once or twice at intervals of from three to seven days. A total dose of about 240 r given through four portals was usually sufficient for the treatment of the entire spinal column. This total was administered in the course of one week in most cases. The series was repeated when symptoms recurred, after intervals varying between six weeks and seventeen months.

It should be noted that the penetrations used were lower, and the doses given smaller, than those of the methods recommended by other workers or practiced in most other institutions. But an increase of kilovoltage, of the number of roentgens, or of both, failed invariably to bring about improvement in patients not previously treated, and resulted in recurrence of pain in cases in which relief had been obtained by means of the radiation technique above described. All being equal, increase of milliamperage (up to 25 ma.), while shortening the periods of treatment because of a higher r per minute output, did not produce results as favorable as those to be described presently. It would seem, then, that, in addition to adequate penetration and dos-

age, the time factor plays a definite part in this form of radiation treatment.

In order to exclude overlapping of the results of different therapeutic measures, all other types of treatment, including rest and analgesics, were discontinued several days before and throughout the period of roentgen therapy. Bedridden patients were taken out of bed as often and for as long as possible. All of the patients treated were incapacitated by pain and entirely stiff before roentgen treatment. Few of them were able to walk.

Of these 17 patients, 7 were cases of Stage III, 6 of Stage II, and 4 of Stage I. In 2 cases of Stage III, roentgen treatment did not produce any result. These patients were in poor health generally, and the whole spine was ankylosed. In the 5 other cases of Stage III pain subsided completely a few days after termination of the first series of treatments. Vertebral mobility did not increase, but the patients stated that they felt more movable, probably owing to the disappearance of pain and muscle spasm. The 6 patients of Stage II responded more dramatically. They felt free of pain almost at once and were able to resume work within a week after termination of the first series of treatments. Four of them returned for treatment at intervals of four to seventeen months because of recurrence of pain and stiffness, and experienced the same relief after these second series of treatments. Photographic records showed that vertebral movements did not actually increase although the patients themselves believed that their mobility had become almost normal. In the 4 cases of Stage I, the therapeutic results were even better. Two of these patients who were entirely incapacitated and had been bedridden for over one month prior to treatment, unable to walk without being supported by two attendants, and in continuous severe pain, began walking unaided two days after the first series of treatments was completed, and were able to resume heavy farm work two weeks later. In the 2 other patients of Stage I, the pain and disability were not equally severe, and the treatment resulted in complete relief of the symptoms. All these patients had been observed during periods of from two to fourteen months prior to the treatment, and no similar therapeutic results had been obtained by any other method. The results of roentgen therapy were permanent; symptoms did not recur during the eighteen months subsequent to the treatment.

Spontaneous improvement being known to occur,[26] the results of roentgen therapy were tested by submitting the patients to the following experiment. The roentgen therapy equipment used included a water-cooling system with an electric pump making a loud humming sound. This pump could be operated independently, without generating roentgen rays. It was impossible for the patients to know whether they received radiation or not. Of the 8 persons tested in the experiment, one stated that he had "perhaps" felt some relief from pain after a series of pseudotreatments. The other 7 patients felt no improvement after pseudotherapy, but experienced complete relief from symptoms after real roentgen treatment. This would seem to indicate that the effect of radiation therapy in these cases is not psychologic, but caused by the roentgen rays.* Since, as mentioned above, no other mode of treatment was given during and after roentgen therapy, the results cannot be attributed to some concurrent therapeutic measures.

It is difficult to understand the mechanisms responsible for this therapeutic effect. In a large number of patients with rheumatoid arthritis of peripheral joints treated from 1927 to 1941 with roentgen rays of variable penetrations and doses, directed to the joints themselves, the vas-

* Two months after the present paper had been accepted for publication an article dealing with similar experiments by C. J. Smyth, R. H. Freyberg, and W. S. Peck, appeared in *J. Am. M. Ass.*, 1941, *116*, 1995–2001. With a slightly different experimental method, these authors found that mental factors do not play an important rôle in the treatment of Strümpell-Marie disease. They recorded excellent results of roentgen therapy with higher penetrations and larger doses than those which I used.

cular system of the extremities, or the vertebral segments which correspond to the nerves supplying the involved peripheral joints, no improvement of symptoms or lesions could be observed by the writer. One may therefore be inclined to ascribe the favorable influence of roentgen therapy upon arthritis of the apophyseal joints to the analgesic effect of roentgen irradiation. But a surprising change of the roentgenologic appearances was observed to occur in the apophyseal joints of 4 patients after treatment (Fig. 3 and 9). The joint spaces, clouded and apparently filled with bone before treatment, became radiolucent and clearly defined after treatment. Perhaps the radiation therapy caused a calcification or ossification of the capsule to disappear, in analogy to the effect upon calcifications in bursae and tendons. A spontaneous retrogression in untreated patients did not occur. No definite change in the roentgen findings took place after treatment in advanced cases. It seems that, in addition to its analgesic effect, roentgen therapy has a favorable action upon the articular lesion itself.

These observations, although necessarily small in number because incipient stages are so rarely observed, show that cure consisting of disappearance of symptoms as well as lesions can be achieved by means of roentgen therapy at early stages of Strümpell-Marie disease. At more advanced stages, relief from pain resulting in subjective improvement of mobility can be obtained, but the anatomical condition can no longer be improved. The lesion is reversible at early stages, but irreparable when the articular cartilage is severely damaged.[16] Hence the need for an early diagnosis.

The practical conclusion which can be drawn from this study may be worded as follows. When a patient suffers from pain in the back or neck and the mobility of the involved region is limited for more than a few weeks, a roentgen examination of the spine, including a study of the apophyseal joints with an adequate technique, should be made, even when the symptoms subside temporarily. A male between twenty and thirty years old should be examined with particular care in the presence of these symptoms; but both sexes and all age groups may be affected. If the roentgen findings suggest an incipient rheumatoid arthritis of one or a number of apophyseal joints, roentgen therapy with small doses and intermediate penetration should be instituted at once. To wait for ossification to appear in the vertebral ligaments or for the sacroiliac joints to become involved in order to confirm the diagnosis of Strümpell-Marie disease means depriving the patient of the one chance of cure he has at the present stage of our knowledge: once the lesion has advanced beyond the reversible stage, the gradual transformation of a healthy young adult into an invalid stricken with pain and immobility can rarely be halted.

XV. SUMMARY

1. Clinical and roentgenologic observations, verified by control series, showed that pain in the spine associated with limitation of vertebral movements is usually caused by lesions of the apophyseal joints.

2. Lesions of the apophyseal joints conform to the conception of arthritis both anatomically and on the basis of their clinical manifestations. Lesions of the vertebral symphyses—the joints formed by the intervertebral discs—have neither the anatomic nor the clinical characters of arthritis.

3. The lesion associated with the clinical syndrome of Strümpell-Marie disease consists in a rheumatoid arthritis of the apophyseal joints (atrophic spondylarthritis). Rarefaction of vertebral bodies and ossification of vertebral ligaments may become superadded, but do not always occur; when present, they are signs of an advanced stage of the disease.

4. Like atrophic arthritis of the peripheral joints, atrophic spondylarthritis, although it is a potentially ankylosing lesion, does not lead in every case to bony ankylosis between the facets. Like atrophic arthritis of peripheral joints, it may become quiescent or arrested before ankylosis takes

place and features of hypertrophic arthritis may then become superimposed upon the original lesion.

5. Pain in the spine and limitation of vertebral movements occur at incipient as well as at advanced stages of atrophic spondylarthritis. They are caused by the lesion of the apophyseal joints and do not depend upon secondary changes such as ossification of ligaments or rarefaction of vertebral bodies.

6. At initial and early stages of atrophic spondylarthritis, complete cure, with disappearance of the lesions roentgenologically, can be achieved by roentgen therapy with small doses and intermediate penetration. At more advanced stages, the lesion itself is irreparable, but roentgen therapy is useful in controlling pain and in producing thereby a subjective improvement of vertebral mobility.

7. The need for an early diagnosis based on roentgen examination of the apophyseal joints is stressed in view of these limitations of therapy.

Acknowledgments. Mr. R. Lawford Knaggs, formerly Professor of Surgery in the University of Leeds, has taken great interest in this study and has encouraged the publication of the findings although they differ from those which he recorded in his own articles. The trend of the presentation was influenced by advice received from Dr. Stuart Carter Dodd, Professor of Sociology, and Dr. Edmund Mayer, Professor of Pathology, American University of Beirut. Dr. George W. Saleeby and Mr. Karnig M. Sarrafian, Department of Roentgenology, have cooperated in collecting and recording the data. The writer is sincerely indebted to them all.

REFERENCES

1. BRYCE, T. H. Osteology and Arthrology. Quain's Elements of Anatomy. Vol. IV, part I, p. 225. Eleventh edition. London, 1915. Also, Gray, H. Anatomy of the Human Body. Twenty-second edition. Philadelphia and New York, 1930, p. 281.
2. CONNOR, B. Letter to Sir Charles Walgrave, giving an account of an extraordinary human skeleton, etc. Philosophical Transactions, 1700.
3. FAGGE, C. H. A case of simple synostosis of the ribs to the vertebrae, and of the arches and articular processes of the vertebrae themselves, and also of one hip joint. *Tr. Path. Soc., London*, 1877, *28*, 201–205.
*4. FINEMAN, S. Rôle of the roentgenologist in diagnosis and treatment of chronic arthritis. *Med. Clin. North America*, 1937, *21*, 1641–1661.
5. FRAENKEL, E. Ueber chronische ankylosierende Wirbelsäulenversteifung. *Fortschr. a d. Geb. d. Röntgenstrahlen*, 1903–1904, *7*, 62–90.
6. GOLDING, F. C. Spondylitis ankylopoietica (spondylitis ossificans ligamentosa). *Brit. J. Surg.*, 1936, *23*, 484–500.
*7. HENCH, P. S., *et al.* The problem of rheumatism and arthritis; review of American and English literature for 1938. *Ann. Int. Med.*, 1940, *13*, 1655; 1837.
*8. HORWITZ, T., and SMITH, R. M. Anatomical, pathological and clinical study of intervertebral joints of the lumbar spine and of the sacroiliac joints. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 173–186.
9. KNAGGS, R. L. Spondylitis deformans. *Brit. J. Surg.*, 1925, *12*, 524–546.
10. KNAGGS, R. L. Report on the Strangeways Collection of Rheumatoid Joints in the Museum of the Royal College of Surgeons. *Brit. J. Surg.*, 1932–1933, *20*, 113; 309; 425.
*11. LANGE, MAX. Die Wirbelgelenke. Die röntgenologische Darstellbarkeit ihrer krankhaften Veränderungen und ihre Beziehungen zu der verschiedenen Erkrankungen der Wirbelsäule. Second edition. F. Enke, Stuttgart, 1936.
12. LÉRI, A. Études sur les affections de la colonne vertébrale. Masson et Cie, Paris, 1926.
13. LERICHE, R. Physiologie normale et pathologie du tissu osseux. Masson et Cie, Paris, 1939.
*14. MARIE, P. Sur la spondylose rhizomélique. *Rev. de méd.*, 1898, *18*, 19–48.
15. MARIE, P., and LÉRI, A. Examen du rachis dans un cas de spondylose rhizomélique. *Bull. Soc. méd. d. hôp.*, Feb. 24, 1899.
*16. OPPENHEIMER, A. Diseases of the apophyseal (intervertebral) articulations. *J. Bone & Joint Surg.*, 1938, *20*, 285–313. Also, The apophyseal intervertebral articulations, roentgenologically considered. *Radiology*, 1938, *30*, 724–740.
17. OPPENHEIMER, A., and TURNER, E. L. Discogenetic disease of the cervical spine with segmental neuritis. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *37*, 484–493.
18. OPPENHEIMER, A. The swollen atrophic hand *Surg., Gynec. & Obst.*, 1938, *67*, 446–454.
19. OPPENHEIMER, A. Calcification and ossification of vertebral ligaments (spondylitis ossificans ligamentosa): roentgen study of pathogenesis and clinical significance. *Radiology*, 1942, *38*, 160–173.

* Contains further bibliographic references.

20. Pemberton, R. Arthritis and Rheumatic Conditions: Their Nature and Treatment. Lea & Febiger, Philadelphia, 1930.
21. Poynton, F. J. Quoted by Hench, *et al.*[7]
22. Rhein, J. H. W. Pathologic report of nervous system in case of spondylose rhizomélique. *J. Am. M. Ass.*, 1908, *51*, 463–467.
23. Scott, S. G. Radiology and the rheumatic backache. *J. Roy. Inst. Pub. Health & Hyg.*, 1938, *1*, 236–244. (Quoted by Hench, *et al.*[7])
24. Simmonds, M. Ueber Spondylitis deformans and ankylosierende Spondylitis. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1903–1904, *7*, 51–62.
25. Sivén, V. O. Zur Kenntnis der sogen. chronisch ankylosierenden Entzündung der Wirbelsäule. *Ztschr. f. klin. Med.*, 1903, *49*, 343–376.
26. Strümpell, A. Bemerkung über die chronisch ankylosierende Entzündung der Wirbelsäule und der Hüftgelenke. *Deutsche Ztschr. f. Nervenh.*, 1897, *11*, 238–243.
27. Wagoner, G., and Pendergrass, E. P. Intrinsic circulation of the vertebral body, with roentgenologic considerations. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 818–826.

VOL. 49, NO. 1

CHONDRODYSTROPHIA CALCIFICANS CONGENITA

By GERARD RAAP, M.D.
Dade County Hospital
MIAMI, FLORIDA

CONRADI,[2] in 1914, first described a condition of this type and stated that he could find no case of similar type in the literature. Although somewhat similar instances have since been reported under a varied nomenclature, which shows a tendency toward a classification under chondroplasia, the generic term chondrodystrophia appears to be more logical and we have only added the two descriptive adjectives to define this group of sporadically reported cases.

Ours is apparently the first example in which a familial and congenital characteristic is proved and in which opportunity has been afforded to investigate 4 cases over a period of time, together with postmortem examinations of the material in one instance.

In October, 1938, there were submitted to us roentgengograms of the chest and long bones in the case of a male child aged ten months (Case I) with a requisition which read under the caption "Clinical Remarks—the twin of this one died suddenly last night." In this case we reported a slight haziness in both lung fields due to an acute respiratory infection and then with reference to the long bones, flaring of the distal ends of the ulnae and tibiae, together with the mottled granular appearance in the ankles, wrists and other joints which in contour follows that of the bony structures in normal ossification, but presents angular densifications rather than rounded densities. This child also showed clinical manifestations of a pneumonia, together with numerous red cells in the urine, with practically no other abnormalities. The temperature rose to 103° F. on the second day, then subsided to normal on the fourth day. Blood count was 3,500,000 erythrocytes, 17,000 leukocytes, 60 per cent hemoglobin, normal differential. The blood count returned to normal in about one week, and the patient has been clinically normal ever since.

Permission was granted to exhume the deceased male twin (Case II) and films were made. These showed joint changes exactly similar to those of the living twin. All organs were examined grossly and microscopically and the cause of death from the history and microscopic sections was attributed to a pneumonia of the right lower lobe. From the history it would appear that this child had been ill for several days previously. On the basis of a possible metallic poisoning, the organs were subjected to chemical analysis and proved negative for the presence of bismuth, arsenic or lead.

The bones of the ankle were removed together with masses of cartilaginous material for histologic study. The microscopic report is as follows: "Sections show an increase of fibrous tissue of periosteal character. Directly under this periosteum a formation of cartilage is noted. The deeper cells are acquiring a cartilaginous character. The deepest layers of cells form osteoid tissue, which is partly calcified. There is no evidence of malignancy."

Several hours were spent in delving into a history of the entire family which included an older child aged two and a half (Case IV), father, mother and both grandmothers, with special reference to type of feeding. The mother was a nurse, who gave us intelligent information but no relevant points were obtained. About two weeks later she was delivered of another male child (Case III) which shows the same changes. A two and a half year old girl, also examined, shows normal bony structures, except for a few punctate densities in both wrists and ankles which suggest that she may previously have had the same changes. The parents show normal bony structures in these areas.

We have been able to follow these chil-

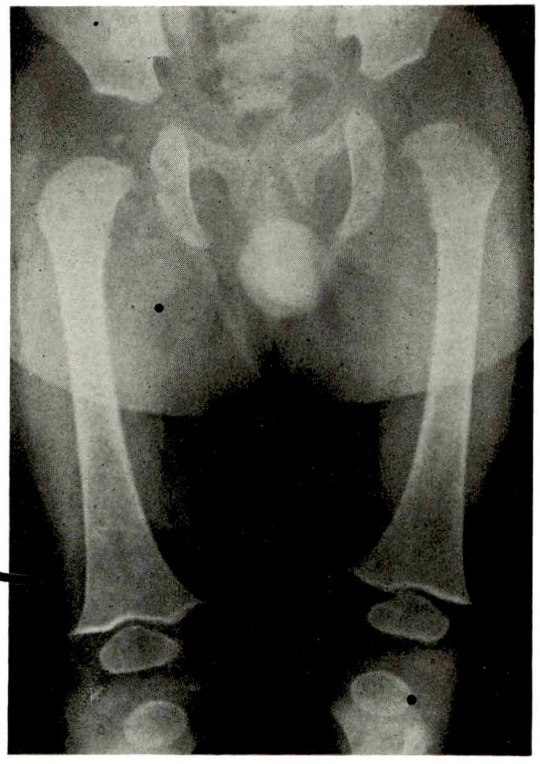


FIG. 1. Case 1. Male living twin at ten months, October, 1938, showing calcium deposits in hip joints and knees.

dren for almost four years. Apparently these abnormal calcifications are marked at birth and disappear by the age of about three years. All were subjected to calcium, phosphorus, cholesterol and phosphatase determinations, blood counts and serologic studies, and no unusual features were discovered. The roentgen studies of all other bony structures show no evidence of dwarfism or cretinism, and rickets and scurvy are ruled out by the dietary history, the chemical findings and the roentgen studies of other bony structures.

Conradi was able to observe his patient roentgenologically and clinically and also made histologic examinations. His patient was a child, female, three months old on admission, suffering from "haematoma of the scalp and head." The femurs showed thickened epiphyses with thin diaphyses. The right was shorter than the left. All four extremities were strikingly shorter and thicker than normal. Fingers and toes were thick and short. No chemical evidences of syphilis. Roentgen findings: The changes were most marked in the distal ends of the femurs and in the tarsal bones. The distal femoral epiphyses were stippled, likewise the tarsal bones, with peculiar shot-like shadows. The distal tibial and fibular epiphyses were affected also, while the upper tibial and fibular epiphyses were only slightly involved.

Tisdall and Erb[11] in 1924, reported 2 cases, the first of which at five weeks presented roentgenographically "peculiar irregular calcareous deposits in the epiphyses at both ends of the humeri, the proximal ends of the radii, ulnae, tibiae, fibulae and distal ends of the femora. The patellae were practically outlined by these deposits. Unfortunately, no films were made of other areas and there were no deposits in the skin or muscles." Films of the elbows and knees are shown which in many respects resemble

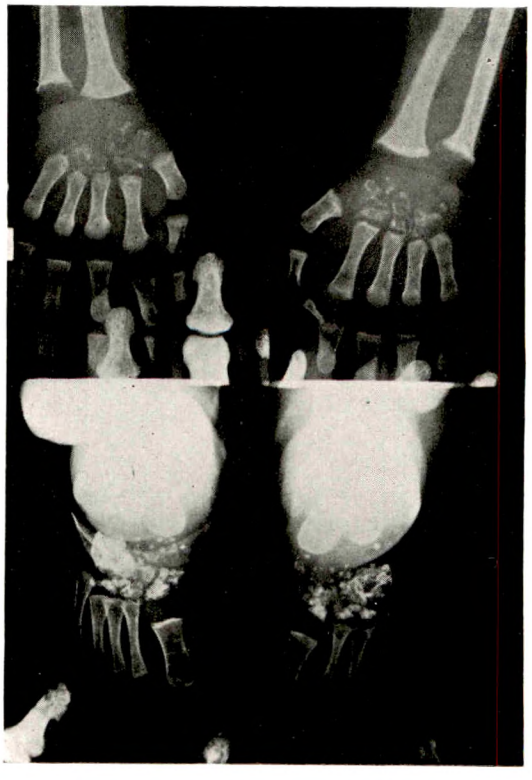


FIG. 2. Case 1. Living twin at ten months. Note calcific deposits in wrists and ankles.

the present cases. Microscopic sections of the patella show a vacuolated appearance in which nuclei have disappeared. There are calcareous deposits in areas of degenerated connective tissue. Here, however, we are dealing also with a syphilitic infection which may account for this degeneration. Blood calcium was 9.3 and 9.7 mg. per 100

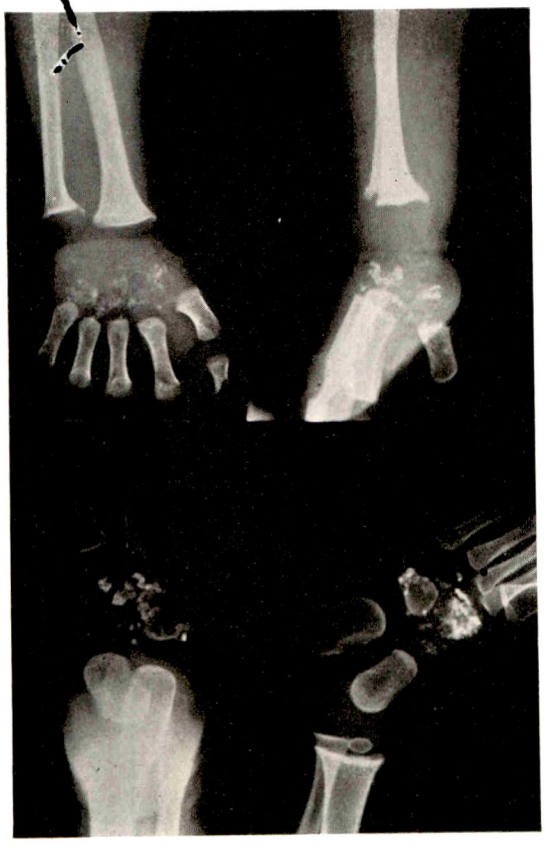


Fig. 3. Case II. Male deceased twin at ten months. October, 1938.

cc. and phosphorus 4.5 and 4.4 mg. per 100 cc.

Geyman[4] differentiates the appearance of luetic lesions of the congenital type and calls attention to Kaufmann's description of three forms of chondrodystrophy, hypoplastic, malacic and hyperplastic, and also remarks that chondrodystrophy is frequently confused with cretinism, although occasional cases of unilateral chondrodystrophia are seen.

Hünermann[5] in 1931 reported a case of a

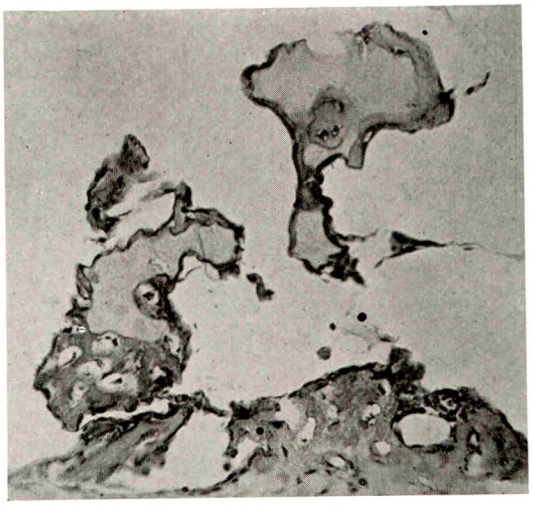


Fig. 4. Microscopic section from ankle of Case II.

female child, aged three weeks, whom he had the opportunity of observing for almost two years. The roentgen findings were innumerable dense, small, stippled shad-



Fig. 5. Roentgenograms of removed sections from ankles and wrists in Case II.



Fig. 6. Case 1 at twenty months. Note gradual disappearance of these deposits.

ows, of varied shapes, in the epiphyses of the extremities as well as along the spinal column and in the pelvis. The skull and facial bones were not affected. These stippled shadows were found in the proximal epiphyses of the humeri, the proximal epiphyses of each radius, the distal end of the left humerus and the proximal end of the right ulna. The right femur was shorter than the left, the heads and neck of each femur were affected, the distal epiphyses of the femurs, the upper epiphyses of the tibias, distal epiphyses of the tibias and the bones of each ankle joint. The carpal bones showed a few stippled shadows. The bony structure of the shafts throughout was normal. Hünermann quotes Conradi, Dietrich and Wiskott, all of whom published similar cases. The roentgen findings are not those of typical chondrodystrophia fetalis or achondroplasia in that the thickened shafts of the long bones due to endosteal and periosteal change are not present. There is also no shortening of all long bones of the extremities. There is also no broadening of the diaphyseal ends.

Hünermann's case was identical clinically and roentgenologically with those of Conradi and Dietrich. He described Conradi's histological findings. Based on these histological findings, Conradi decided the disease process was an abortive form of chondrodystrophy or achondroplasia.

In 1938, Reilly and Smyth[7] described the stippled epiphyses of congenital hypothyroidism. Although the most typical cases described showed hypothyroidism as a most evident factor, it is stated that it may also occur without hypothyroidism. Their article also emphasizes the similarity to Legg-Calvé-Perthes' disease. Such a similarity is not suggested in our cases, and the

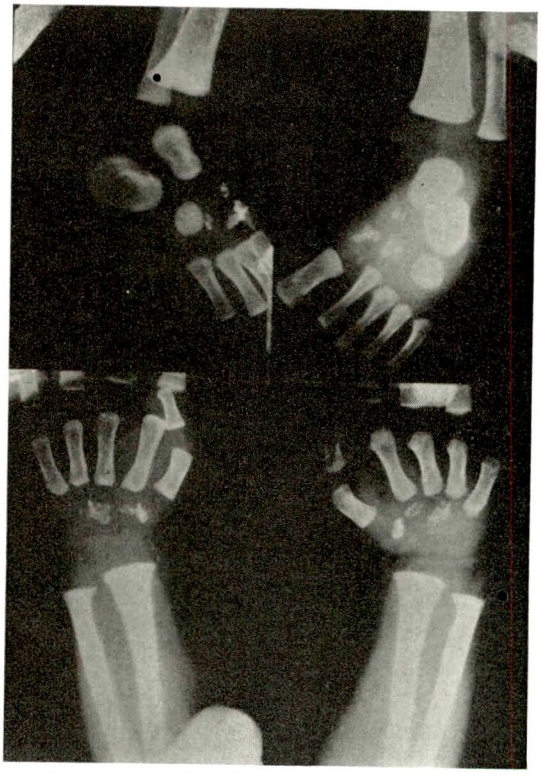


Fig. 7. Case III. Male, aged ten days. December, 1938. Appearance of ankles and wrists proves that these changes are present at birth.

evidence of hypothyroidism is entirely absent. The stippling is confined to the epiphyseal centers alone and is not present in the cartilage.

Maitland[6] reports the case of a female child, three days old, weighing 7 pounds, with enlarged knee and elbow joints, somewhat spastic, showing marked developmental changes in the cervical and dorsal vertebrae together with shortening of the extremities and punctate calcifications in the knees and elbows but with very little in the wrists and ankles. A previous child born in 1935, in the same family, had similar changes and lived only nine months. In these cases there is a marked element of developmental anomaly, since the father also shows absence of certain phalanges in the hands. This is apparently a story of transmitted notochordal anomalies.

Attention is directed to the fact that in all previous reports of a disturbance of this nature, there were evident extenuating factors such as developmental variants, syphilis, cretinism, hypothyroidism. In our cases the children are apparently normal in every other respect living under ordinary conditions of life. We have been able to observe these changes without medication or attempt to vary this abnormal condition.

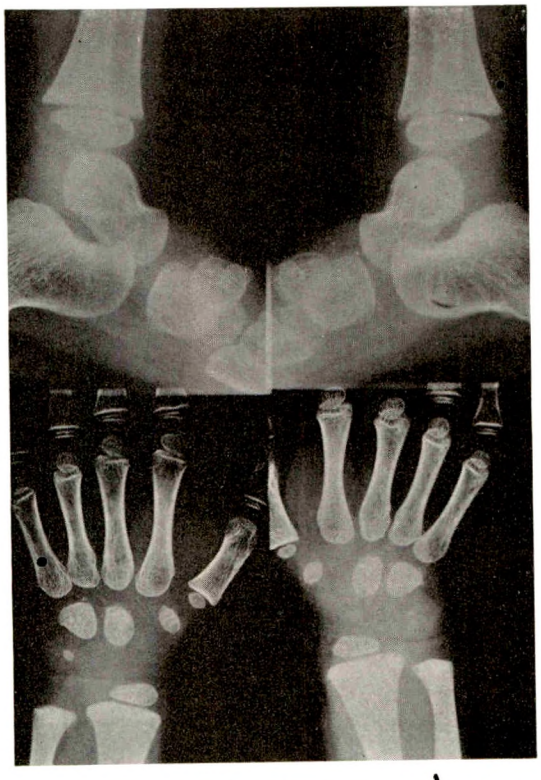


Fig. 8. Case iv. Female, aged two and one-half years. Shows persistence of calcific deposits.

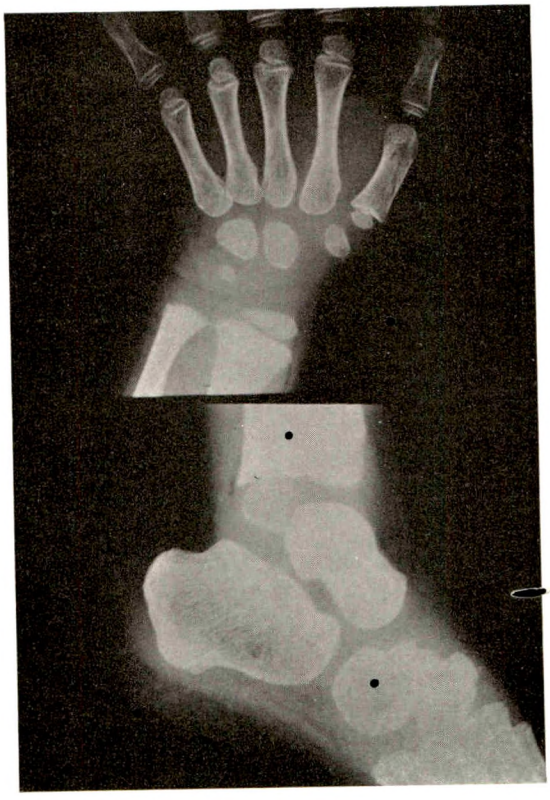


Fig. 9. Case iv, aged four years. Deposits have practically disappeared.

REFERENCES

1. Bloxsom, A., and Johnston, R. A. Calcinosis universalis with unusual features. *Am. J. Dis. Child.*, 1938, *56*, 103–109.
2. Conradi, E. Vorzeitiges Auftreten von Knochen- und eigenartigen Verkalkungskernen bei Chondrodystrophia fötalis hypoplastica. Histologische und Röntgenuntersuchungen. *Jahr. f. Kinderh.*, 1914, *80*, 86–97.
3. Dietrich. Case report. Fortschrift zur Feier des 10 jahrigens Bestehens der Akademie für praktische Medizin in Koln, 1915.
4. Geyman, M. J. An unusual manifestation of epiphyseal and joint pathology in a new-born infant. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 868–870.
5. Hünermann, C. Chondrodystrophia calcificans

congenita als abortive Form der Chondrodystrophie. *Ztschr. f. Kinderh.*, 1931, *51*, 1–19.

6. MAITLAND, D. G. Punctate epiphyseal dysplasia occurring in two members of the same family. *Brit. J. Radiol.*, 1939, *12*, 91–93.
7. REILLY, W. A., and SMYTH, F. A. Stippled epiphyses with congenital hypothyroidism (cretinoid epiphyseal dysgenesis). AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 675–681.
8. SIEGERT, F. Die Osteogenesis chondrodysplastica mit besonderer Berücksichtigung des Pseudoepiphysen-Problems. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1933, *48*, 666–682.
9. SILFVERSKIOLD, N. A "forme fruste" of chondrodystrophia with changes simulating several of the known "local malacias." *Acta radiol.*, 1925, *4*, 44–57.
10. SNOKE, P. O. Chondrodystrophia fetalis. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 31–42.
11. TISDALL, F. F., and ERB, I. H. Report of two cases with unusual calcareous deposits. *Am. J. Dis. Child.*, 1924, *27*, 28–38.
12. WISKOTT. Case report. *München. med. Wchnschr.*, 1929, 34.

VOL. 49, NO. 1

THE PREVENTION OF IRRADIATION SICKNESS

USE OF VITAMIN B_1 IN ROENTGEN THERAPY

By WILLIAM H. WHITMORE, M.D.
NORFOLK, VIRGINIA

THE symptoms of malaise, anorexia, nausea, and vomiting, associated with or following irradiation with roentgen rays or the gamma rays of radium have been called roentgen or radium sickness. This illness has been a disturbing complication since the beginning of the massive dose or intensive type of roentgen and radium therapy. Many theories have been advanced as to the cause of this sickness, and considerable research work has been done, but as yet, the exact nature of the changes producing the constitutional symptoms have not been determined.

The symptoms of irradiation sickness may start shortly after or some hours after a single moderate or large dose of radiation, or in some cases the day following the treatment; when the fractional method of giving radiation daily in small or moderate sized doses is used, the sickness may not develop until the second week or later. There is marked variation in the susceptibility of individuals, and in the severity of symptoms. In mild cases there is general languor and malaise, with anorexia and slight nausea; in moderately severe cases there is more nausea with occasional vomiting; in the more severe cases there is marked nausea with frequent vomiting, weakness and prostration. Usually there is constipation, probably due to the low food intake, but in a few cases diarrhea is present, which may be a part of the irradiation sickness but more frequently is due to the direct effect of the irradiation on the intestinal tract, in abdominal and pelvic cases. Irradiation of the abdomen, pelvis, breast and lower thorax are more likely to cause irradiation sickness than treatment of other parts of the body.

Some of the theoretical causes of roentgen sickness that have been suggested are:

(*a*) gases produced by the corona and high tension electric field;
(*b*) an electric field surrounding the body of the patient;
(*c*) chemical changes produced in the body by irradiation;
(*d*) general influence of irradiation on the body and absorption of the products of cell destruction;
(*e*) irradiation effects on certain organs of internal secretion;
(*f*) nervous strain and psychic influences;
(*g*) destruction of intestinal mucosa.

Pfahler[12,13] in 1916 and 1918 reported his observations and experiments relating to the cause and prevention of roentgen sickness. His experiments with guinea pigs indicated some toxic element in the air from around the tube. By protecting his patients from the contaminated air and providing fresh air with oxygen inhalations during treatments, he was able to reduce the incidence of roentgen sickness to about one-third of the previous frequency.

It seems very probable that there was a psychic factor in some of the cases of roentgen sickness; unpleasant odors may increase nausea, regardless of the primary cause; in the past, patients often complained of the odor in the treatment room, and some of them became nauseated as soon as they entered the room. It is probable that the incidence of true roentgen sickness is the same with modern equipment as it was with the old type, and that the apparent reduction of incidence with modern equipment is due to the elimination of the false roentgen sickness cases which were due to psychic influences and the toxic effects of the gases generated around the high tension leads and the roentgen tube. Certainly such gases are not a factor in true irradiation sickness, as this frequently develops during radium therapy or during treatments with modern coronaless equipment.

Jones and Roth[9] found the effect of im-

proved ventilation only temporary and apparently more psychic then real; they did not find that acidosis was a factor in these cases; they noted that the region of the body treated was an important factor, and that irradiations of the abdomen, breast and lower thoracic areas were most likely to cause symptoms; they concluded that irritation of the vagus nerve was a cause of constitutional symptoms.

Béclère[2] considered, from a physiological standpoint, that the effects of irradiation on the nerves were the underlying cause of the symptoms; that the symptoms may be due to the effect of the rays on nerve endings or sympathetic ganglia, or that the ray caused the passage into the blood of some substance that has emetic properties. Béclère noted that the constitutional symptoms frequently followed irradiation of tumor masses which resolved rapidly, and stated that "from clinical data it would appear that the chief cause of the disturbance . . . is the passage into the blood stream of certain soluble substances, more or less toxic, resulting from the disintegration of normal and pathological cellular elements. To this must be added, . . . the direct effects of the penetrating rays upon the ganglionic nervous system of the viscera."

Doub, Bolliger and Hartman[3,4] studied the metabolic changes following roentgen therapy. Their equipment was arranged to avoid any effect from the gases or the high tension electric field, with no part of the high tension apparatus or roentgen tube in the room with the patient or experimental animal, and with a grounded metal shield between the subject and the high tension parts. From their observations on 23 patients and experiments on dogs, they reported:

(*a*) that there was an increase in the acid soluble phosphorus coincident with nausea, vomiting and alkalosis;
(*b*) no distinct change in the CO_2 combining power of the blood; they found alkalosis with initial depression of the hydrogen ion concentration;
(*c*) sugar content of the blood increased after irradiation, in dogs an immediate rise;
(*d*) marked decreases in amino acids of the blood, suggesting that the protoplasm of the irradiated cells remains intact during the early stages, and that there is increased enzymic activity producing deamidation with resultant increase in the blood sugar;
(*e*) marked decrease in non-protein nitrogen during the first hours with later increases of 75 to 100 mg. per 100 cc. of blood in dogs receiving a lethal or near lethal dose of roentgen rays;
(*f*) slight decrease in blood calcium, considered as probably secondary to the increased phosphorus;
(*g*) an immediate large increase in the phosphorus content of the blood, interpreted as an index of acute nuclear destruction.

From their findings they suggest that irradiation sickness is due to the immediate products of nuclear destruction.

Arons and Sokoloff[1] considered that the effect of irradiation on the reticulo-endothelial system was a factor in roentgen sickness; that a small dose of the rays stimulates the reticulo-endothelial cells, and that a larger dose inhibits or destroys the defense mechanism of this system.

Morgan[11] was of the opinion that roentgen sickness was due to too rapid administration of the rays in the massive dose technique, and advocated fractional doses, giving the required dosage in ten days to two weeks; in some cases he divided the daily dose, giving a fraction of the dose each hour from 9 A.M. to 6 P.M. He reported that roentgen sickness was generally not produced by such fractional dosage. Extreme fractionating of doses is not a practical method of therapy when many patients are to be treated and the total dose for each patient relatively large.

Various treatments for irradiation sickness have been proposed and tried. Some have been of value in improving the psychic and bodily comfort of the patient, such as the elimination of noxious gases and providing fresh air in treatment rooms;[13] the sedatives frequently employed have reduced the severity of the symptoms, but have increased the anorexia.

TABLE I

BRIEF REPORT OF EACH OF 122 CASES

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
1. Mrs. N.B.	43	Menorrhagia	9-18-38 to 10- 8-38	2-15×15 (c)	1,600	Thiamin 6 mg.; nausea 0; appetite good
2. Mrs. E.F.	50	Cancer uterine stump	10-25-38 to 11-29-38	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
Rules 3. Miss L.B.	54	Cancer right breast, and skin metastases	10-27-38 to 11-30-38	3-10×15 1-10×10 (a)	8,000	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
			3- 9-39 to 4- 8-39	2-10×15 (a)	4,000	
			6- 7-39 to 6-27-39	3-10×15 (d)	6,210	
4. Mrs. L.E.R.	54	Cancer fundus uteri	10-27-38 to 11-23-38	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea slight; appetite fair
5. Mrs. G.H.	25	Cancer cervix uteri	10-28-38 to 11-15-38	4-10×15 (b)	6,100	Thiamin 6 mg.; liver; calc.; nausea 0; appetite improved
6. Mrs. J.O.C.	60	Cancer cervix uteri	11-21-38 to 12-21-38	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite poor
7. Mrs. C.H.D.	49	Cancer cervix uteri	11-21-38 to 12-20-38	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite improved
8. Mrs. W.L.H.	71	Cancer right breast	11-22-38 to 12-29-38	3-10×15 2- 8×10 (a)	9,000	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
9. Mr. D.T.R.	53	Cancer lung	11-21-38 to 12-21-38	5-10×15 (c)	12,250	Thiamin 6 mg.; liver; codeine (for pain); nausea 0; appetite poor
10. Mrs. A.K.R.	65	Cancer bladder	11-29-38 to 12-27-38	2-10×15 1-10×10 1- 8×10 (f)	9,400	Thiamin 0.6 mg. (error); liver; calc.; nausea severe; thiamin 9 mg.; nausea 0 after 2 days; appetite fair
11. F.M. (F)	51	Cancer left breast	12- 2-38 to 1- 7-39	4-10×15 1- 8×10 (a)	9,900	Thiamin 6 mg.; calc.; nausea 0; appetite good

* Voltage, filtration and focal skin distance indicated as:

(a) 200 kv., 0.5 mm. Cu, 1.0 mm. Al; 50 cm. focal skin distance;
(b) 200 kv., 0.5 mm. Cu, 1.0 mm. Al; 70 cm. focal skin distance;
(c) 200 kv., 1.0 mm. Cu, 1.0 mm. Al; 50 cm. focal skin distance;
(d) 140 kv., 0.25 mm. Cu, 1.0 mm. Al; 50 cm. focal skin distance;
(e) one portal, 15×15 cm., (d); other portals (a);
(f) 200 kv., 0.42 mm. Sn, 0.25 mm. Cu, 1.0 mm. Al; 50 cm. focal skin distance;
(g) 220 kv., 1.05 mm. Sn, 0.25 mm. Cu, 1.0 mm. Al; 50 cm. focal skin distance.

† Measured in air, without backscatter.

‡ Amount of thiamin listed is the daily dosage of thiamin chloride. "Liver" indicates concentrated liver extract (usually reticulogen), containing thiamin chloride, 0.5 cc. intramuscularly, three times weekly. "Calc. indicates calcium salts, usually compound gluconate and dicalcium phosphate, 1 gram, three times daily.

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm *	Total Dosage in Roentgens†	Medication; Comments‡
12. Mr. E.D.B.	46	Sarcoma thyroid	12-21-38 to 12-31-38	2- 9×12 (f)	6,000	Thiamin 0; nausea moderate; thiamin 6 mg.; calc.; nausea 0 after 2 days
			4-13-39 to 5-20-39	1- 8×10	2,450	
13. Mrs. E.K.	55	Cancer corpus uteri	12-20-38 to 1-19-39	6-10×15 (b)	11,400	Thiamin 6 mg.; liver; nausea 0; appetite fair
14. Mr. J.V.R.	54	Cancer floor of mouth, and glands of neck	12-27-38 to 1-27-39	2- 6× 8 1-6 cm. (f)	13,000	Thiamin 6 mg.; liver; nausea slight; appetite poor (dysphagia)
			5- 5-39 to 5-24-39	2-10×10 (f)	4,400	
15. Mrs. V.S.	60	Cancer left breast, preoperative; postoperative	12-19-38 to 12-30-38	3-10×15 1- 8×10 (a)	3,600	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
			2-22-39 to 3-12-39	3-10×15 1- 8×10 (a)(d)	6,000	
16. Mr. J.T.W.	67	Cancer glands right neck	1- 6-39 to 2- 6-39	1-10×10	5,000	Thiamin 6 mg.; liver; nausea 0; appetite good
			9-30-39 to 10-25-39	1- 8×10 2- 6 cm. (f)	2,700 6,000	
17. Mr. J.E.E.	50	Lymphoblastoma of stomach	1- 5-39 to 1-30-39	2-15×15 (g)	8,200	Thiamin 6 mg.; liver; calc.; nausea slight
18. Mrs. R.W.J.	46	Cancer cervix uteri	2- 8-39 to 3- 4-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea slight, occasionally; appetite fair
19. Mrs. B.H.	48	Cancer corpus uteri	2- 9-39 to 3- 4-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
20. Mrs. W.A.G.	56	Cancer cervix and corpus uteri	3- 6-39 to 3-28-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
21. H.B. (F)	30	Cancer cervix uteri	3- 7-39 to 4- 3-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite good
22. Mrs. J.P.C.	56	Cancer right breast postoperative	3-14-39 to 4-10-39	3-10×15 1- 8×10 (a)	7,200	Thiamin 0, 2 weeks; nausea, moderate; thiamin 6 mg.; nausea 0; appetite improved
23. Mrs. B.P.	57	Cancer vulva and inguinal metastases	3-14-39 to 3-30-39	1-15×15 1- 8×10 1- 5 cm.	4,000 6,000	Thiamin 6 mg.; liver; calc.; nausea 0; appetite good
			4-25-39 to 5-22-39	1-10×10 (f)		
24. Mrs. J.A.G.	45	Cancer right breast; sterilization	3-20-39 to 5- 4-39	3-10×15 1- 8×10 4-10×15 (a)(c)	6,600 3,200	Thiamin 6 mg.; liver; nausea 0; appetite fair

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
25. Mr. H.L.H.	65	Cancer in colostomy, from cancer of colon	3-27-39 to 4-19-39	1-10×15 (a) 2- 6× 3 (100 Kv–2. Al)	2,500 4,000	Thiamin 6 mg.; liver; nausea 0; appetite good
26. Mrs. A.P.	51	Cancer cervix uteri	3-29-39 to 4-25-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea slight; appetite good
27. Mrs. L.B.	79	Cancer left breast	3-27-39 to 4-20-39	3-10×15 1- 8×10 (a)	6,450	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
28. Mrs. L.B.	65	Cancer left breast	4- 3-39 to 5- 6-39	3-10×15 1- 8×10 (a)	8,200	Thiamin 6 mg.; liver; nausea 0; appetite very good
29. Mr. J.L.C.	65	Cancer prostate	4-17-39 to 5-13-39	3-10×10 1- 8×10 (f)	10,000	Thiamin 6 mg.; liver; nausea 0; appetite fair
30. Mrs. W.W.U.	41	Cancer cervix uteri	5- 1-39 to 5-27-39	6-10×15 (b)	9,600	Thiamin 6 mg.; liver; nausea moderate (colitis prior to roentgen therapy)
31. Mrs. H.L.S.	77	Cancer left breast	5-12-39 to 6-20-39	3-10×15 1- 8×10 (a)	9,000	Thiamin 9 mg.; liver; calc.; nausea 0; appetite good
32. Mrs. M.G.W.	47	Cancer left breast; sterilization	5-22-39 to 6-22-39	3-10×15 1- 8×10 4-10×15 (a)(c)	7,800 3,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite very good
33. Mrs. E.H.M.	43	Cancer cervix uteri	6- 3-39 to 6-30-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite poor (morphine addict)
34. Mr. E.R.S.	49	Cancer pelvis, metastatic	6-12-39 to 7-14-39	6-10×15 (b)	11,700	Thiamin 6 mg.; liver; nausea slight; appetite fair
35. Mrs. E.H.H.	62	Cancer cervix uteri	6-12-39 to 7-10-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite good
36. V.W. (F)	40	Cancer right breast	6-13-39 to 7-24-39	4-10×15 1- 8×10 (a)	10,350	Thiamin 6 mg.; calc.; nausea slight; appetite fair
37. Mr. J.A.W.	64	Cancer right buccal mucosa	6-27-39 to 7-28-39	2- 6× 8 1- 6 cm. (f)	11,150	Thiamin 9 mg.; nausea 0; appetite very good
38. Mrs. J.B.	50	Cancer left breast, postoperative, recurrent	7- 5-39 to 7-27-39	1-10×13 (d)	2,500	Thiamin 6 mg.; nausea 0; appetite fair
39. Mrs. L.D.T.	65	Cancer cervix uteri	7-11-39 to 8- 9-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite good
40. Miss H.L.W.	50	Bilateral cancer of breast, preoperative, postoperative	7-17-39 to 7-29-39 8- 8-39 to 10- 2-39	4-10×15 2-15×15 2- 8×10 2-10×15 2-15×15 2- 8×10 (a)(e)	7,200 9,600	Thiamin 9 mg.; liver; calc.; nausea 0; appetite good

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
41. Mrs. G.C.B.	47	Cancer cervix uteri	7-17-39 to 8-14-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea o; appetite good
42. Mr. G.B.T.	71	Cancer bladder	7-17-39 to 8-16-39	3-10×10 1- 8×10 (f)	10,000	Thiamin 6 mg.; liver; calc.; nausea o; appetite good
43. Mrs. S.W.Z.	49	Cancer left breast	8-15-39 to 9-12-39	3-10×15 1- 8×10 (a)	7,800	Thiamin 6 mg.; liver; nausea o; appetite very good
44. Mrs. F.B.P.	71	Cancer left breast	7-25-39 to 8-12-39	1-10×15 2- 8×10 1- 6× 8 (a)	4,800	Thiamin 6 mg.; liver; nausea o; appetite poor
45. Mrs. F.W.H.	79	Cancer right breast	8-21-39 to 9-18-39	2-10×15 1- 8×10 (a)	6,450	Thiamin 9 mg.; liver; nausea o; appetite good
46. Mr. J.S.	61	Cancer metastatic neck	8-25-39 to 9-22-39	2- 8×10 (f)	6,000	Thiamin 6 mg.; codeine (for pain); nausea o; appetite poor
47. Mrs. W.P.C.	57	Cancer lower lip; metastases in neck	9- 5-39 to 10- 7-39	2- 6× 8 2- 6 cm. (f)	11,200	Thiamin 6 mg.; liver; nausea o; appetite poor
48. Mr. C.B.	73	Cancer larynx	9-11-39 to 10-2-39	2- 8×10 (f)	7,000	Thiamin 6 mg. increased to 9 mg.; nausea o; appetite improved
49. Mrs. M.T.	48	Cancer cervix; recurrent	9-14-39 to 10-18-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea o; appetite very good
50. Mrs. E.B.S.	83	Cancer right breast	9-15-39 to 10-16-39	2-10×15 2-10×10 1- 8×10 (a)	9,000	Thiamin 6 mg.; liver; calc.; nausea o; appetite good
51. V.B. (F)	48	Cancer cervix uteri	9-18-39 to 10-18-39	6-10×16 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea o; appetite improved
52. Mr. J.B.	28	Cancer metastases in neck	9-25-39 to 11- 1-39	4- 8×10 (a)	12,000	Thiamin 6 mg.; liver; nausea o; appetite good
53. Mrs. J.F.	36	Cancer left buccal mucosa	9-28-39 to 10-30-39 11- 7-39 to 11-28-39	1- 8×10 2- 6× 8 (f) 1- 3 cm. (a)	9,000 3,500	Thiamin 6 mg.; liver; nausea o; appetite poor
54. Mr. H.A.C.	53	Cancer right forearm, with epitrochlear and axillary metastases	10-16-39 to 12-14-39	3-10×15 3-10×10 1- 8×10 (a)(f)	16,000	Thiamin 6 mg.; nausea o; appetite good
55. Mrs. J.S.	66	Cancer right breast	10-16-39 to 11-11-39	3-10×15 1- 8×10 (a)	9,000	Thiamin 9 mg.; liver; calc.; nausea o; appetite improved

Table I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
56. A.H. (F)	65	Cancer cervix uteri	10-16-39 to 11-15-39	4-10×15 (c)	7,800	Thiamin 6 mg.; liver; nausea 0; appetite fair
57. Mrs. K.B.M.	33	Cancer cervix uteri	10-19-39 to 11-15-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea moderate; thiamin increased to 9 mg.; nausea relieved; appetite improved
58. Mrs. I.B.	49	Cancer left femur metastatic from breast	10-24-39 to 11-29-39	3-15×20 (f)	7,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
59. L.W. (F)	58	Cancer left breast	10-31-39 to 11-29-39	3-10×15 1- 8×10 (a)	7,200	Thiamin 6 mg.; nausea 0; appetite good
60. Mrs. M.J.B.	54	Cancer cervix uteri	11- 7-39 to 12-30-39	6-10×15 (b) 1- 3 cm. (a)	9,900 5,820	Thiamin 6 mg.; liver; calc.; nausea slight; thiamin increased to 9 mg.; nausea 0; appetite improved
61. Mrs. A.O.S.	56	Cancer cervix uteri	11- 8-39 to 12-11-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite fair
62. Mr. A.V.P.	60	Cancer bladder	11- 9-39 to 12-11-39	3-10×10 1- 8×10 (f)	10,000	Thiamin 6 mg.; liver; nausea 0; appetite good
63. Mrs. F.H.S.	45	Cancer corpus uteri	11-13-39 to 12- 9-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea 0; appetite very good
64. Mrs. J.E.E.	36	Cancer cervix uteri	11-27-39 to 12-23-39	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite improved
65. Mr. J.S.E.	66	Sarcoma testis, with inguinal and pulmonary metastases	12-13-39 to 1-15-40	4-15×15 1-15×20 (c)	4,500	Thiamin 6 mg.; liver; nausea 0; appetite poor
66. Mrs. F.H.	60	Cancer left breast, preoperative and postoperative	12-13-39 to 12-27-39 1-22-40 to 2-12-40	3-10×15 1- 8×10 (a) 1-15×15 1- 8×10 (e)	3,600 3,000	Thiamin 6 mg.; nausea 0; appetite good
67. Mrs. H.H.A.	40	Cancer right breast, postoperative; sterilization	12-18-39 to 1-12-40 1-15-40 to 2-22-40	1-10×15 1-15×15 1- 8×10 (e) 2-15×15 (c)	5,400 2,200	Thiamin 6 mg.; liver; nausea moderate after pelvic treatments; appetite fair
68. Mrs. J.C.D.	59	Cancer left breast, preoperative and postoperative	1-15-40 to 1-27-40 3- 4-40 to 3-20-40	3-10×15 1- 8×10 (a) 1-10×15 1-15×15 1- 8×10 (e)	3,600 4,500	Thiamin 6 mg.; liver; nausea 0; appetite good

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
69. Mrs. C.C.F.	66	Cancer larynx	2- 5-40 to 3- 2-40	2- 6×8 (f)	7,000	Thiamin 6 mg.; nausea slight; appetite poor
70. Mrs. M.D.P.	60	Cancer cervix uteri	2- 5-40 to 3- 2-40	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea o; appetite fair
71. Mrs. T.M.	50	Cancer left breast, post-operative; sterilization	2-26-40 to 3-22-40	2-10×15 1-15×15 1- 8×10 2-15×15 (e)(c)	6,600 1,800	Thiamin 6 mg.; liver; nausea o; appetite improved
72. Mr. O.H.C.	50	Cancer nose, face, left ear, and metastases in neck	2-12-40 to 3- 2-40 3-19-40 to 4- 5-40	1- 6×8 1- 7×8 (f) 1- 8×10 (a)	6,600 2,500	Thiamin 6 mg.; nausea o; appetite improved
73. Mrs. J.B.A.	57	Cancer cervix uteri	2-19-40 to 3-16-40	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; calc.; nausea slight; appetite fair
74. Mrs. M.F.	58	Cancer corpus uteri	2-27-40 to 3-29-40	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea o; appetite good
75. Mrs. P.A.	64	Cancer of bladder	3- 4-40 to 4-11-40	3-10×10 (f)	7,500	Thiamin 9 mg.; liver; nausea o; appetite good
76. Mrs. M.E.D.	77	Cancer of tongue and floor of mouth	3-13-40 to 4-11-40	2- 6×8 (f)	6,000	Thiamin 9 mg.; liver; nausea o; appetite fair
77. Mr. L.H.S.	44	Cancer of lung and mediastinum	3-18-40 to 4-29-40	2-10×20 3-10×15 2- 8×10 (c)	15,450	Thiamin 9 mg.; liver; nausea o; appetite improved
78. Mr. S.H.D.	65	Cancer of neck, secondary to lupus	3-18-40 to 4- 8-40	1-10×12 (f)	3,000	Thiamin 6 mg.; nausea o; appetite fair
79. Mrs. J.G.T.	60	Cancer of bladder	3-27-40 to 4-26-40	3-10×10 (f)	7,200	Thiamin 9 mg.; liver; nausea slight; appetite fair
80. Mrs. T.B.S.	50	Cancer right breast; sterilization	4- 2-40 to 5-17-40	3-10×15 1- 8×10 (a) 2-15×15 (c)	7,800 1,800	Thiamin none at start; nausea moderate; thiamin 9 mg.; nausea o; appetite improved
81. Dr. C.W.D.	63	Prostatic hypertrophy	4- 5-40 to 5- 3-40	2-10×15 (b) 1-12×12 1- 8×10 (f)	8,200	Thiamin 9 mg.; liver; did not take full amount, developed nausea; resumed full dosage, nausea o; appetite improved
82. Mrs. I.B.	69	Cancer cervix uteri	4- 6-40 to 5- 3-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; calc.; nausea o; appetite improved

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
83. Mrs. C.R.F.	48	Uterine fibroids	4- 8-40 to 5- 1-40	2-15×15 (c)	2,500	Thiamin 6 mg.; liver; nausea moderate 1 week; thiamin 9 mg.; nausea 0; appetite good
84. Mr. F.B.H.	45	Cancer of bladder (case not completed) (transferred)	4- 8-40 to 5- 1-40	2-10×15 1-12×12 (f)	4,800	Thiamin 6 mg.; liver; nausea slight; thiamin 9 mg.; nausea 0; appetite improved
85. Dr. J.W.M.	71	Cancer of bladder	4- 9-40 to 5- 8-40	2-10×15 1-12×12 1- 8×10 (f)	9,800	Thiamin 9 mg.; liver; nausea 0; appetite good
86. Mrs. W.N.H.	54	Cancer corpus and cervix uteri	4- 9-40 to 5- 6-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; nausea moderate in 2nd week; relieved by thiamin 6 mg., hypo. q. 2 days; appetite improved
87. Mr. W.R.B.	56	Cancer of bladder	4-11-40 to 5-11-40	2-10×10 1-10×12 1- 8×10 (f)	9,600	Thiamin 9 mg.; liver; nausea 0; appetite good
88. Mrs. G.L.C.	72	Cancer left breast	4-29-40 to 5-28-40	3-10×15 1- 8×10 (a)	8,700	Thiamin 6 mg.; liver; nausea 0; appetite fair
89. Mrs. M.M.	39	Menorrhagia	5-13-40 to 5-31-40	2-15×15 (c)	1,800	Thiamin 6 mg.; nausea slight; appetite fair
90. Mrs. J.B.E.	63	Cancer right breast	5-24-40 to 6-21-40	3-10×15 1- 8×10 (a)	7,950	Thiamin 6 mg.; liver; nausea 0; appetite good
91. Mrs. A.W.R.	54	Cancer cervix uteri	6- 1-40 to 6-28-40	6-10×15 (b)	10,200	Thiamin 6 mg.; liver; nausea 0; appetite very good
92. Mr. W.P.F.	43	Cancer of lung	6-14-40 to 7-20-40	2-14×18 1-10×15 (c)	7,500	Thiamin 9 mg.; liver; nausea 0; appetite good
93. Mrs. I.M.S.	54	Cancer right breast, recurrent	6-17-40 to 7-15-40	3-10×15 1- 8×10 1- 6× 8 (a)	7,800	Thiamin 6 mg.; nausea 0; appetite good
94. Mrs. J.L.W.	58	Cancer right breast post-operative	6-17-40 to 7-12-40	1-10×15 1-15×15 1- 8×10 (e)	5,400	Thiamin 6 mg.; liver; nausea 0; appetite very good
95. Mr. H.A.	58	Cancer esophagus	6-24-40 to 8-14-40	4-18×15 (f)	10,000	Thiamin 9 mg.; liver; nausea 0; appetite poor (dysphagia)
96. Mrs. J.H.D.	55	Cancer corpus uteri	6-25-40 to 7-20-40	4-10×15 (b)	7,400	Thiamin 9 mg.; liver; nausea moderate on 4th day; thiamin increased to 15 mg.; nausea relieved; appetite improved

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
97. Mrs. H.H.H.	46	Cancer pelvis, metastatic from breast	7- 2-40 to 8- 8-40	6-10×18 (f)	10,800	Thiamin 9 mg.; liver; nausea 0; appetite good
98. Mr. C.W.M.	47	Mediastinal neoplasm	7- 6-40 to 8-28-40	2-12×18 (c)	4,800	Thiamin 9 mg.; liver; nausea 0; appetite good
99. Mrs. W.B.H.	59	Cancer cervix uteri	7- 8-40 to 8- 3-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; nausea 0; appetite improved
100. Mrs. G.H.	63	Cancer cervix uteri	7-10-40 to 8- 7-40	4-10×15 (b)	8,400	Thiamin 9 mg.; liver; nausea 0; appetite good
101. Mr. E.H.	36	Seminoma, abdominal metastasis	7-22-40 to 8-29-40	4-15×20 (f)	6,000	Thiamin 9 mg.; liver; nausea 0 up to 8-20-40; 8-21-40 severe nausea with vomiting; 8-22-40 thiamin chloride 60 mg. by hypo.; 8-23-40 to 8-29-40, 30 mg. thiamin, daily, by hypo.; completed therapy without further nausea or vomiting; appetite improved
102. Mrs. P.R.	40	Cancer cervix uteri	7-29-40 to 8-24-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; nausea slight during 4th week; appetite fair
103. Mrs. C.P.	60	Cancer left breast, postoperative	8- 6-40 to 9-11-40	1-10×15 1-15×15 1- 8×10 (e)	4,950	Thiamin 6 mg.; liver; nausea 0; appetite good
104. Mrs. J.F.D.	60	Cancer corpus uteri, with abdominal metastases	8- 8-40 to 9- 6-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; nausea 0, up to 8-22-40, complained of slight nausea; 8-26-40, nausea moderate; thiamin increased to 18 mg., by hypo. once, then 9 mg. hypo., daily. No further nausea, and appetite improved
105. Mrs. E.K.	53	Tumor, left breast, preoperative	8-21-40 to 9- 9-40	3-10×15 (a)	3,600	Thiamin 9 mg.; liver; nausea 0; appetite good
106. Mrs. D.L.	48	Chromophobe adenoma of pituitary	9-16-40 to 10- 3-40	2- 8×10 2- 6× 8 (f)	3,200	Thiamin 0 at start; nausea severe after first week; thiamin, 9 mg. hypo., 9-24-40, then 9 mg. per os daily; nausea 0; appetite improved
107. Mrs. R.C.B.	48	Cancer cervix uteri and vagina	9-19-40 to 11- 4-40	6-10×15 (b) 1- 4 cm. (a)	10,200 4,800	Thiamin 9 mg.; liver; nausea 0; appetite improved
108. Mrs. H.W.C.	59	Cancer cervix uteri	9-19-40 to 10-17-40	6-10×15 (b)	10,200	Thiamin 9 mg.; liver; nausea 0; appetite very good

TABLE I—*Continued*

Case No. and Patient	Age	Diagnosis	Duration of Treatment	No. of Portals; Size in cm.*	Total Dosage in Roentgens†	Medication; Comments‡
109. Mr. J.E.C.	67	Cancer of bladder	9-23-40 to 10-26-40	3-10×10 1- 8×10 (f)	10,000	Thiamin 9 mg.; liver; nausea 0; appetite very good
110. Mrs. J.D.	52	Cancer cervix uteri	10- 1-40 to 10-28-40	6-10×15 (b)	10,000	Thiamin 9 mg. hypo. 1st day, then 9 mg.; liver; nausea 0 or slight(?); appetite good
		(Had severe nausea with vomiting during radium therapy-, without thiamin)				
111. Mrs. E.P.	53	Tumor, left breast, preoperative	10 4-40 to 10-17-40	3-10×15 (a)	3,600	Thiamin 9 mg.; nausea 0; appetite good
112. Mr. V.B.H.	52	Cancer prostate	10-10-40 to 11-19-40	1-10×12 2-10×10 1- 8×10 (f)	9,400	Thiamin 9 mg.; liver; nausea 0, appetite good
113. D.S. (F)	44	Cancer anterior thoracic wall, postoperative both breasts	10-11-40 to 10-31-40	2-15×20 (d)	3,600	Thiamin 9 mg.; nausea 0; appetite improved
114. Mrs. M.H.	79	Cancer of bladder	10-14-40 to 11-22-40	3-10×10 1- 8×10 (f)	8,500	Thiamin 9 mg.; liver; nausea 0; appetite improved
115. Mrs. H.F.A.	38	Cancer left breast, postoperative; sterilization	10-14-40 to 11-18-40	1-10×15 1-15×15 1- 8×10 2-15×15 (e)(c)	5,400 2,250	Thiamin 9 mg.; liver; nausea slight, one day after each pelvic treatment; appetite good
116. Miss E.S.	63	Cancer of bladder	10-14-40 to 11-20-40	3-10×10 1- 8×10 (f)	8,500	Thiamin 9 mg.; liver; nausea 0; appetite good
117. Mrs. K.D.	49	Endometrial hyperplasia	10-16-40 to 11- 8-40	2-10×10 1-15×15 (c)	3,300	Thiamin 9 mg.; nausea 0; appetite good
118. Mrs. W.H.B.	56	Cancer left breast	10-21-40 to 11-18-40	3-10×15 1- 8×10 (a)	7,200	Thiamin 9 mg.; liver; nausea 0; appetite good
119. Mrs. F.G.J.	58	Cancer left breast, postoperative	10-21-40 to 11-12-40	1-10×15 1-15×15 1- 8×10 (e)	5,400	Thiamin 9 mg.; nausea 0; appetite very good
120. Mrs. W.J.W.	32	Cancer of lungs metastatic from ovary	10-24-40 to 11-19-40	5-10×20 (c)	5,800	No thiamin at first; nausea in 2nd week; thiamin 9 mg.; nausea 0; appetite improved
121. Mrs. J.C.E.	50	Menorrhagia	10-30-40 to 11-19-40	2-15×15 (c)	1,800	Thiamin 9 mg.; nausea 0; appetite good
122. Mrs. L.S.	29	Endometrial hyperplasia	11- 2-40 to 11-19-40	2-15×15 (c)	1,800	Thiamin 9 mg.; nausea 0; appetite good

Schreiner and Stenström[16] advocated reducing the treatment time by increasing the power to the tube, active elimination before treatment, high intake of fluids and alkaline drinks, and 1,000 cc. of salt solution or 2 per cent solution of sodium bicarbonate per rectum after each treatment. In their report they state that with this regimen "unpleasant symptoms, with the exception of headache, nausea and vomiting, are rare."

Doub, Bolliger and Hartman[3,4] found other sedatives, especially codeine and luminal have been used rather widely and freely.

Young[17] reported good results with the use of liver extract, and referred to reports by Dietel and by Webster on the use of this preparation. Young gave an average daily dose of 2 cc. of liver extract, sometimes as much as 4 cc. daily; he reported 30 cases, with complete relief in 53 per cent, some benefit in 23 per cent, and no benefit in 23 per cent.

TABLE II

SUMMARY OF 122 CASES

Daily Amount of Thiamin Chloride	No. of Cases	Nausea 0	Nausea Slight	Nausea Moderate	Nausea Severe	Nausea, Vomiting Severe
Less than 6 mg.	6	0	2 (33%)	3 (50%)	1 (17%)	0
6 mg.	79	62 (78%)	14 (18%)	3 (4%)	0	0
9 mg.	46	36 (78%)	7 (16%)	2 (4%)	1 (2%)	0
Over 9 mg.	9	9 (100%)	0	0	0	0
Over 6 mg., totals	134*	107 (79.8%)	21 (15.7%)	5 (3.8%)	1 (0.7%)	0

* This table is a summary of 122 cases; 12 cases are listed in two groups, due to changes in dosage of thiamin during therapy. Ninety-three of the 122 patients received concentrated liver extract, containing 6 mg. of thiamin chloride per cc., 0.5 cc. three times weekly; 35 of these patients also received calcium salts, 1 gram t.i.d.

that the administration of calcium reduced the acute sickness, also that morphine, glucose, and ether anesthesia relieved the symptoms.

Richards and Peters[15] used 1½ to 3 grains of nembutal given one hour before each treatment, or 2 grains of nembutal in suppositories. In their series of cases they found that 1 out of 40 would not tolerate barbiturates, and that 4 out of 40 developed resistance to the drug. They also gave diluted hydrochloric acid to combat the anorexia. Popp and Binger[14] also found pentobarbital sodium of value in reducing the incidence of nausea and vomiting, and

Martin and Moursund[10] observed that animals deprived of vitamin B_1 developed symptoms similar to those with roentgen intoxication; they found that animals given lethal doses of roentgen rays and then treated with vitamin B_1 survived or lived longer than the control animals. Their experiments suggested that vitamin B_1 gave some protection against roentgen intoxication.

Johnston[8] has recently reported that vitamin B_1 seems to be the medication which offers the most relief in roentgen sickness; in extreme cases she found that vitamin B_1 with small doses of nembutal gave satisfac-

tory results. Imler and Wammock[7] reported 21 cases treated with vitamin B_1, given hypodermatically, and state that roentgen sickness is controlled rapidly and effectively by the administration of vitamin B_1 in large doses.

The report of Martin and Moursund[10] suggested that the undesirable and unfavorable effects of irradiation might be minimized or relieved by the administration of vitamin B_1, which is a simple procedure and a not too expensive one if it would relieve the symptoms of irradiation sickness. This sickness, in its severe form, is not of very frequent occurrence, but is most likely to develop in those who are least able to withstand its effects, that is, in patients undergoing treatment for cancerous conditions. These patients are often poorly nourished, frequently anemic from blood loss, and often feeble from age and disease. It is in such cases that the rule, "treat the patient rather than the disease," must be followed, and frequently the treatment of the disease by radium or roentgen rays has been suspended or modified on account of the severe constitutional symptoms of irradiation sickness. Often, too, patients who were in good condition at the start of radiation treatment lost strength and weight, and became weak and feeble, after four or five weeks of roentgen treatments, with associated irradiation sickness; such patients required a prolonged convalescence to recover from the effects of radiation treatment. The sedative drugs, nembutal, luminal, codeine, and morphine, gave some relief but increased the anorexia, resulting in increased weakness and loss of weight. Frequently the fluid intake was so reduced that dehydration was a factor in increasing the debility.

Roentgen sickness of the severe type is not as frequent with the present methods of treatment with modern equipment as it was some years ago, but it is still far from uncommon. A very high percentage of patients undergoing radium or roentgen therapy experience mild symptoms, such as malaise and anorexia, which are accepted as a necessary part of the treatment. In any large series of therapy cases, between 10 and 20 per cent may be expected to develop more than mild symptoms of irradiation sickness, and without treatment most of these will have increasingly severe symptoms with continued irradiation.

Beginning in October, 1938, a series of patients undergoing treatment with 200 kv. roentgen rays were given thiamin chloride, synthetic vitamin B_1, in addition to other supportive and stimulative measures. These patients were all treated in the office, and their diets could not be supervised, but they were advised and encouraged to take a diet including liberal amounts of milk, eggs, fruits and fruit juices. Concentrated liver extract,[11] usually reticulogen, was given in 0.5 cc. doses, intramuscularly, three times weekly in more than two-thirds of the cases; calcium salts[3,4] were given to more than one-fourth of the cases, generally as the compound of calcium gluconate and dicalcium phosphate, 1 gram three times daily. Thiamin chloride was prescribed in 3 mg. tablets, each tablet equivalent to 1,000 international units of vitamin B_1; two tablets daily were ordered as the routine dose; if any nausea developed or the appetite was poor, this dosage was increased to three, four, or more tablets daily. Recently, the minimum dose was increased to three tablets, or 9 mg., daily, with additional amounts of thiamin as indicated. In most of the pelvic and abdominal cases, a pyramidal dose technique was used, starting with 100 r to each of two fields daily and increasing the amount of radiation each fourth day up to 500 r or more daily. This allowed time for the effect of the vitamin B_1 before the larger amounts of radiation were delivered.

This program of supportive treatment was not planned to test or prove the efficacy of vitamin B_1 therapy, but was started as an attempt to offset some of the unfavorable effects of roentgen therapy and to improve the condition of the patients during

the treatment period; for that reason, no control series of cases, without vitamin B_1 medication, was prepared.

The results have been most gratifying; in a series of 122 consecutive cases, in which roentgen irradiation was given to areas of the neck, thorax, abdomen, and pelvis, there was not one case of roentgen sickness of sufficient severity to require modification or suspension of the planned course of treatment; every case that developed nausea, or nausea and vomiting, was relieved or improved by increasing the dosage of vitamin B_1; in a few cases fairly large doses of thiamin chloride were given hypodermatically to relieve nausea. Many of the patients noticed an improvement in their appetites after a week or more of treatment; most of the patients improved in their general condition and sense of well being during the course of roentgen therapy, which was in marked contrast to our previous experience with patients undergoing similar courses of therapy. Sedatives and hypnotics were avoided, and were prescribed in only a few cases for pain or insomnia.

In some cases the value of thiamin was clearly demonstrated. Case 10, Mrs A. K. R., treated for cancer of the bladder, 11-29-38 to 12-27-38, developed severe nausea with vomiting; it was discovered that an error had been made in filling her prescription so that she was taking 0.3 mg. tablets instead of 3 mg. tablets; she was given 9 mg. of thiamin chloride, daily, per os, and after two days there was complete relief from nausea.

In Cases 12, 22, 80, 106, and 120, thiamin was not prescribed at the start of the roentgen treatments; in each case nausea developed after some days of treatment, and was relieved after administration of thiamin, usually in one or two days.

Case 81, a physician, did not take the full prescribed amount, 9 mg., of thiamin daily; in the third week of treatment he developed moderately severe nausea; he was given 0.5 cc. of concentrated liver extract containing 3 mg. of thiamin, intramuscularly, repeated three times weekly, and 9 mg. of thiamin chloride per os daily; his nausea was relieved and his appetite improved; he was able to continue at work and completed his treatments in very good condition.

Several cases developed slight or moderate nausea on a daily dosage of 6 mg. of thiamin; increasing the dose to 9 mg., or more, gave relief and generally improved the appetite; Case 96 required an increase to 15 mg. daily to relieve the nausea.

Case 49, Mrs. M. T., aged forty-eight, with recurrent cancer of the cervix uteri, had been treated in 1937 with 200 kv. roentgen rays; during the entire course of that treatment she had been nauseated, with some vomiting and no appetite, and was very weak at the completion of the course: she was treated from 9-14-39 to 10-18-39, through six 10×15 cm. portals, using roentgen rays generated at 200 kv., with 1.0 mm. copper and 1.0 mm. aluminum filters, pyramidal dosage, total of 10,200 r, measured in air; she was given 6 mg. of thiamin, daily, by mouth, and 0.5 cc. of reticulogen intramuscularly three times weekly; she did not develop any nausea, maintained a good appetite, and continued at work during the entire course of therapy.

Case 94, Mrs. J. L. W., aged fifty-eight, in 1938 was given roentgen treatments following a radical left mastectomy; she suffered from anorexia and nausea during the treatments, with loss of weight and strength. Following radical right mastectomy, roentgen treatments were given from 6-12-40 to 7-12-40, during which the patient was given 6 mg. of thiamin daily, and 0.5 cc. of reticulogen three times weekly; she had no nausea, maintained a good appetite, and gained several pounds in weight during the month of treatment.

Cases 70, 75, 82, 99, 102, and 110, had been severely nauseated during radium treatments preceding the roentgen treatments. During the period of the roentgen therapy, with thiamin administration, there was slight or no nausea.

Case 101, with abdominal metastasis from seminoma of the testis, developed se-

vere nausea and vomiting after eighteen days of treatment; he was given 60 mg. of thiamin hypodermatically, then 30 mg. daily; the course of roentgen therapy was completed without further nausea, and with improvement in the patient's appetite.

SUMMARY

The literature of irradiation sickness has been reviewed, in part, and certain theories and methods of treatment abstracted from published reports. One hundred and twenty-two cases are reported, who were given thiamin, some of whom also received concentrated liver extract and calcium salts, during the period of roentgen therapy; these cases received treatment over fairly large areas of the neck, thorax, abdomen and pelvis (see Table 1). A considerable percentage of such cases would be expected to develop moderate to severe symptoms of roentgen sickness.

Any degree of nausea admitted or complained of by the patient was considered an indication of irradiation sickness; these cases were graded in four classes: slight nausea, moderate nausea, severe nausea with vomiting, and severe nausea and vomiting requiring modification of radiation therapy. Of the cases given 6 mg. or more of thiamin chloride daily, 79.8 per cent had no symptoms of irradiation sickness; 9 cases given more than 9 mg. of thiamin daily had no symptoms of irradiation illness. Table II shows the division of the cases according to the amount of thiamin given and the degree of symptoms of irradiation sickness.

CONCLUSIONS

The various theories as to the causes of roentgen sickness do not explain all of the clinical changes noted. None of the theories explain why a small dose of radiation over a moderate sized area of the body in certain individuals will cause rather marked constitutional symptoms, while larger doses in other cases cause no reaction nor any sign of irradiation sickness.

On the basis of the similarity of the symptoms of vitamin B_1 deficiency and those of irradiation sickness,[10] and the clinical results of vitamin B_1 administration in irradiation sickness,[7,8,10] it is suggested that vitamin B_1 is required to metabolize the products of nuclear disintegration or other substances produced in the body by irradiation, and that when there is an adequate supply of vitamin B_1 in the body irradiation sickness does not develop. It is known that vitamin B_1 is required for certain metabolic processes and that its effect is purely functional. In vitamin B_1 deficiency there is anorexia or decreased appetite, decreased tone of stomach and intestinal muscles with constipation, and certain types of nerve disturbances; in irradiation sickness, there is anorexia, nausea, vomiting and constipation.

Irritation sickness may be prevented by the administration of adequate amounts of thiamin chloride; from 6 to 9 mg. daily should be given to patients undergoing radium or roentgen therapy, and if any symptoms of irradiation sickness develop the amount of thiamin should be increased.*

I wish to express my appreciation to Dr. Clayton W. Eley for permission to use the cases on which this paper is based; these cases were all treated in the private service of Dr. Eley.

REFERENCES

1. ARONS, I., and SOKOLOFF, B. Rôle of reticulo-endothelial system in cancer, with reference to congo red therapy in roentgen sickness and anemia. AM. J. ROENTGENOL. & RAD THERAPY, 1939, *41*, 834–850.
2. BÉCLÈRE, A. The "penetrating-irradiations-sickness." AM. J. ROENTGENOL., 1918, *5*, 498–506.
3. DOUB, H. P., BOLLIGER, A., and HARTMAN, F. W. Immediate metabolic disturbances following deep roentgen-ray therapy; preliminary report of experimental and clinical study. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 54–64.
4. DOUB, H. P., BOLLIGER, A., and HARTMAN, F. W. Immediate metabolic disturbances following deep roentgen-ray therapy; prevention and treatment of untoward reactions. *J. Am. M. Ass.*, 1925, *85*, 1299–1303.

* Continued use of thiamin during two more years has strengthened our conviction that administration of an adequate dosage of vitamin B_1 will prevent irradiation sickness.

5. Friedman, H. F., and Drinker, P. Radiation sickness; its possible cause and prevention. Am. J. Roentgenol & Rad. Therapy, 1936, *36*, 503–509.
6. Hall, C. C., and Whipple, G. H. Roentgen-ray intoxication; disturbances in metabolism produced by deep massive doses of hard roentgen rays. *Am. J. M. Sc.*, 1919, *157*, 453–482.
7. Imler, A. E., and Wammmock, H. Vitamin B_1 in irradiation sickness. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 243–249.
8. Johnston, Z. A. Treatment of radiation reactions following 200 kv. therapy. *Radiology*, 1940, *35*, 192–197.
9. Jones, L. L., and Roth, P. Cause of constitutional symptoms following deep roentgenotherapy. Am. J. Roentgenol., 1918, *5*, 32–35.
10. Martin, C. L., and Moursund, W. H., Jr. Treatment of roentgen sickness with synthetic vitamin B_1. Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 620–624.
11. Morgan, J. D. Further observations on the treatment of malignant neoplasms by a fractional radiation technique. Am. J. Roentgenol. & Rad. Therapy, 1925, *13*, 244–246.
12. Pfahler, G. E. Cause and prevention of the constitutional effects associated with the massive doses of deep roentgenotherapy. Am. J. Roentgenol., 1916, *3*, 310–313.
13. Pfahler, G. E. Cause and prevention of the constitutional effects associated with the massive doses of deep roentgenotherapy. Am. J. Roentgenol., 1918, *5*, 5–9.
14. Popp, W. C., and Binger, M. W. Use of pentobarbital sodium for roentgen nausea and vomiting. *Radiology*, 1937, *28*, 211–214.
15. Richards, G. E., and Peters, M. V. Nembutal in the treatment of radiation sickness. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 522–525.
16. Schreiner, B. F., and Stenström, K. W. Consideration of assumed causes of roentgen-ray intoxication and injuries. Am. J. Roentgenol. & Rad. Therapy, 1924, *11*, 451–454.
17. Young, B. R. Liver extract as a remedy for roentgen sickness. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 681–688.

VOL. 49, NO. 1

CLASSIFICATION OF EPITHELIAL CANCERS BASED UPON SITE OF ORIGIN*

By E. A. MERRITT, M.D., *and* RALPH M. CAULK, M.D.
Garfield Memorial Hospital and Warwick Memorial Clinic
WASHINGTON, D.C.

AN INCREASED responsibility is constantly being placed upon the radiologist in the diagnosis and treatment of malignant disease. More and more it becomes necessary to have a broader concept of cancer in general and, specifically, with respect to the individual manifestations.

By and large, prime importance has been placed upon the microscopic aspects of malignancy; but as we become more familiar with the effects of roentgen rays and radium upon the various tissues, we develop increased respect for the tumor bed and the particular region from which the malignant cells have their birth.

The recognition of these factors is highly important as a guide to the type of treatment to be used and the prognosis in the individual case.

Coutard,[1] in his various publications, has repeatedly stressed the importance of the tumor bed and pointed out the example of three lesions, i.e., those of the tonsil, the anterior pillar and the posterior pillar, wherein are presented three different types of malignancy all having their origin within a few millimeters of each other and all capable of enveloping the other in their growth. Each of these manifests a sensitivity that is inherent in its tissue of origin and largely independent of the individual cell type.

Roux-Berger[2] demonstrated that the curability of various lingual lesions depended greatly upon the particular portion of the tongue which was involved.

Cutler, Buschke and Cantril[3] have indexed the subject matter with considerable emphasis upon this concept of tumor origin.

The matter has been brought to our attention more profoundly during the past year when it was decided to review some two thousand cases of cancer which had been treated since 1932 in our own institution. The review was undertaken with a two-fold purpose, namely, to evaluate the results of treatment and at the same time to reclassify the cases so that a more satisfactory cross-index could be instituted and promulgated.

It would seem almost imperative that various workers in this field have a common classification if we are to compare the results of various techniques and methods of treatment.

Lastly, we find it most stimulating to adhere to a rigid classification of this type. An exhaustive study from the standpoint of history, physical examination, roentgen examination and microscopic study is often necessary to accomplish this purpose. The net result in knowledge gained of each particular lesion is well worth the effort.

The proposed classification embraces only the epithelial malignancies with the sole exception of the lymphosarcomas, many of which originate in and about Waldeyer's ring. These are included on the basis of behavior simulating that of the carcinomas.

The numerical listings included in the following classification serve no purpose other than to indicate the relative proportions in which the various lesions have presented themselves in our own series of cases treated between 1933 and 1940 inclusive.

SUPERFICIAL EPITHELIOMAS

Superficial cancers of the face, neck, and scalp constitute by far the greatest percentage of malignant lesions treated by the radiologist. We classify many of these as originating in special localization, such as

* From the radiological clinic of Drs. Groover, Christie, and Merritt. Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

	Cases
1. Face, neck and scalp	523
a. External ear	55
b. External auditory canal	3
c. Eyelid	33
d. Ocular conjunctiva	0
e. Nose	89
f. Lip	103
g. Other lesions of this region without a special tumor bed	240
2. Extremities	37
3. Trunk	11
4. Penis	5
5. Vulva	16
6. Anus	7

upon a cartilaginous base, because they constitute certain problems both as regards treatment and prognosis. Consider, for instance, a carcinoma of the external auditory canal as compared with an epithelioma of the lip, both of which are relatively of very superficial origin, yet the former is rarely curable whereas the latter is just the opposite.

In most discussions of malignancy, epitheliomas of the penis are included with the male generative organs, while those of the vulva are included with the female generative organs. It would seem that their superficial origin demands that they more rightly be placed in the category of superficial epithelioma of special location. The same holds for carcinoma of the anus which usually is included with carcinoma of the alimentary tract; but the picture is that of superficial epidermoid carcinoma and the mere fact that they tend to infiltrate past the mucocutaneous junction into the rectum before they are usually recognized clinically makes them no more a portion of the alimentary tract than does an epithelioma of the lip extending into the mouth make it a carcinoma of the buccal cavity.

NASAL CAVITY

	Cases
1. Turbinates	3
2. Septum	4

It is sometimes difficult to differentiate precisely the site of origin of these lesions. In the first place, there are a relatively small percentage of lesions that originate within this region. One must be careful to differentiate epitheliomas originating in the nasal accessory sinuses, particularly the ethmoids or the antra and invading the nasal fossa secondarily, from primary lesions in this region. It is also sometimes difficult to determine whether lesions which fill the choanae actually originate within the nasal cavity or within the nasopharynx.

NASAL ACCESSORY SINUSES

	Cases
1. Sphenoids	0
2. Frontals	2
3. Ethmoids	3
4. Antra	16

Primary epitheliomas of the sphenoids must be exceptionally rare. Most malignant lesions in this region must originate in the nasopharynx and invade the sphenoid sinus secondarily. Likewise, epitheliomas of the frontal and ethmoid sinuses are seldom seen.

The antra are by far the most common site of malignant degeneration in the nasal accessory sinuses. They often grow to quite large size and may invade either the orbit or the nasal fossa, or the hard palate and superior alveolus before they are recognized clinically. These facts must always be borne in mind when lesions presenting in these locations are submitted for diagnosis and treatment.

ORAL CAVITY

	Cases
1. Alveolus	25
2. Buccal mucosa	26
3. Hard palate	1
4. Tongue	62
a. Dorsum	26
b. Base	14
c. Infralingual portion	22

The infralingual portion of the tongue includes those lesions of the floor of the mouth. At times it is difficult to determine whether a lesion arises on the epiglottis or in the base of the tongue. As stated above, it is also imperative when confronted with a lesion of the hard palate or superior alveolus to eliminate the antrum as a primary site of origin. Dorsal lingual lesions present

an entirely different problem from those of the base of the tongue or infralingual lesions due largely to the dense vasculo-connective tissue constituting the tumor bed.

NASOPHARYNX

1. Roof
2. Posterior wall
3. Lateral wall

Total ..... 15 cases

Lesions of the nasopharynx have usually grown to such a large extent before they are recognized that a precise appraisal of their site of origin is extremely difficult. It would appear, however, that there are at least three definite locations from which these originate. Undoubtedly, some of these lesions must begin in the eustachian tubes although this is extremely difficult to prove.

OROPHARYNX

	Cases
1. Anterior pillar	2
2. Tonsil	34
3. Posterior pillar	1
4. Soft palate	9
5. Free border of the epiglottis	4

Lesions of the tonsil, as is well known, are extremely sensitive and offer an excellent prognosis if found without glands, whereas lesions of the anterior pillar are exactly opposite and are seldom, if ever, curable. Lesions of the soft palate and free border of the epiglottis are quite sensitive to radiation; also, with the latter type, quite prone to exhibit glands, when first seen.

Lesions of the posterior pillar, while exhibiting a moderate degree of sensitivity, are often accompanied by extensive invasion in the lateral and posterior pharyngeal walls.

HYPOPHARYNX

	Cases
1. Lateral pharyngeal wall	4
2. Posterior pharyngeal wall	3
3. Pyriform sinus	9
4. Aryepiglottic fold	1

The close proximity of the hypopharynx and the larynx has led to considerable confusion regarding lesions originating within this region. The otolaryngologist classes many of these as intrinsic and extrinsic carcinoma of the larynx based upon extent of the disease. This is entirely a surgical concept and disregards the fact that a lesion originating within the hypopharynx and involving the larynx secondarily is an entirely different matter from a lesion originating within the larynx involving secondarily the hypophyarynx. A history of hoarseness and dysphagia characterizes malignancies of these sites, and the sequence of development of these two symptoms when both exist is almost a certain clue as to the site of origin.

Hypopharyngeal lesions do not manifest the curability that laryngeal lesions do. Lesions of the posterior pharyngeal wall, while they often manifest a primary sensitivity, tend to infiltrate far upward and downward under the mucosa and are rarely, if ever, sterilized. The same holds for lesions of the lateral pharyngeal wall. Lesions of the pyriform sinus seem to be controlled in a small minority of cases but invasion or recurrence in the constrictor muscles of the esophageal mouth is extremely common and prevents a cure. Lesions of the aryepiglottic fold are at the dividing line between the pharynx and the larynx and are usually either laryngeal or pharyngeal. We have had one lesion originating high up on the free border of the aryepiglottic fold near the point of insertion with the epiglottis that was extremely sensitive.

LARYNX

	Cases
1. Vestibule	12
2. True cord	11
3. Subglottis	2

Vestibular lesions include those epitheliomas originating on the laryngeal face of the epiglottis, the false cord and the ventricular cavity, and manifest a high degree of radiosensitivity and radiocurability when they have not invaded too far. They are prone to earlier glandular involvement than are lesions of the true cord or subglottis, and in this respect they partake very much of the character of hypopharyngeal lesions. It would appear that vestibular lesions are,

for the most part, inoperable even by the most ambitious surgeon.

Lesions of the true cord are most certainly radiosensitive and radiocurable in a large percentage of cases unless they assume primary infiltrative characteristics, as noted by early and complete fixation with or without involvement of the cartilages. Lesions of the subglottis are the most uncommon and must be differentiated from primary lesions of the trachea. The close proximity to the cricoid cartilage with tendency toward infiltration in many instances leads to a poorer prognosis from the standpoint of radiotherapy.

TRACHEA

Total number of cases	3

Carcinoma of the trachea, as one gleans from the literature, must be extremely unusual. We have treated 3 cases in the past eight years, one of which was treated in 1934 and lived without a recurrence until one year ago. The other two have been treated in the last two years and both have been dramatic in their response to irradiation, and remain symptom free to date.

LUNG

Total number of cases	28

We can dismiss this without going further. It seems to be the general consensus that all epitheliomas of the lung are of bronchogenic origin.

ALIMENTARY TRACT

	Cases
1. Esophagus	12
2. Stomach	55
3. Small bowel	0
4. Large intestine	46
5. Rectum	69

Epitheliomas of the large intestine include the rectum from a strictly anatomical standpoint. Its special location, however, with ready accessibility from the anal orifice justifies a separate classification.

LIVER, BILIARY PASSAGES, AND PANCREAS

It is extremely difficult to differentiate the various sites of origin of cancers in this region. Carcinomas of the head of the pancreas and biliary passages are often such an integral part of the entire malignant process discovered either at operation or autopsy that much study is necessary to arrive at a precise diagnosis.

1. Liver	
2. Bile ducts	
3. Gallbladder	
4. Head of the pancreas	
5. Tail of the pancreas	
Total number of cases	11

FEMALE GENERATIVE ORGANS

	Cases
1. Ovary	65
2. Corpus uteri	67
3. Cervix uteri	331
4. Vaginal walls	12

Little need be said regarding carcinoma of the ovary. The diagnosis is usually made at operation and the sensitivity and prognosis will probably ultimately depend upon its degree of dissemination, and second, whether it is a solid or cystic type of tumor, and if solid, the microscopic site of origin as determined by cellular characteristics.

Carcinoma of the corpus uteri must be differentiated from cancer of the cervix, however, and regarding this we have only two things to say: Undoubtedly, we may find an adenocarcinoma of the cervix but it is extremely rare to be presented with an epidermoid carcinoma originating within the corpus; the endocervical origin of many epidermoid carcinomas must always be kept in mind and may exist without visible evidence of ulceration. The differentiation from corpus cancer must be made from the histologic picture.

Regarding epitheliomas of the vaginal walls, as one studies them more carefully they fall into a very small minority and usually represent upward extension from carcinoma of the vulva or downward extension from carcinoma of the cervix.

MALE GENERATIVE ORGANS

	Cases
1. Prostate	59
2. Testicle	20

URINARY TRACT

	Cases
1. Kidney	31
2. Bladder	80
3. Urethra	5

ENDOCRINE GLANDS

	Cases
1. Thyroid	8
2. Parathyroid	1

BREAST

Total number ..... 574 cases

SUMMARY

It is obvious that there are imperfections and difficulties in formulating and applying a classification of this type. Theoretically, and practically, other sites of origin for epitheliomas must exist, as for instance, the lacrimal glands, fallopian tubes, vas deferens, etc. Yet we find that grouped in this classification are embraced the vast majority of all cancers which come to the radiologist for diagnosis and treatment. A cross-index file based upon this classification makes cases readily accessible to follow-up and study. The concept is purely anatomical and is largely divorced from previous surgical or pathologic and microscopic impressions.

REFERENCES

1. COUTARD, H. Results and methods of treatment of cancer by radiation. *Ann. Surg.*, 1937, *106*, 584–598.
2. ROUX-BERGER, J. L. Cancer de la langue (statique de la Fondation Curie). *Bull. et mém. Soc. nat. de chir.*, 1932, *58*, 1343–1353.
3. CUTLER, M., BUSCHKE, F., and CANTRIL, S. T. Cancer: Its Diagnosis and Treatment. W. B. Saunders Co., Philadelphia, 1938.

DISCUSSION

DR. HOWARD P. DOUB, Detroit, Mich. This is a very interesting paper, essentially on the anatomical classification of malignant tumors, without taking into account the pathological cell structure. The regional origin of these tumors connotes to radiologists certain clinical impressions which we have gained over a period of years, and this has been indicated in several instances by the authors. We feel, however, that the pathological classification based on histological sections is also of importance, and has important implications, as it indicates to us in many instances the radiosensitivity of tumors, the probability of metastases, the rate of growth of the tumor, and certain reactions of fibrous tissue.

To radiologists the regional origin of tumors, of course, indicates rather broadly certain clues as to cell type. If the tumor involves the lower lip, it is usually of squamous-cell origin, whereas in other portions of the face it may be of either type, but is usually basal cell in type.

It would have been interesting for Dr. Caulk to give us the type of radiotherapy which he used, either the fractionated type of therapy or the massive dose, the amount of voltage, the number of roentgens, and so forth.

We feel that the tumor bed is an extremely important factor in our treatment of tumors, in our estimation beforehand, how much dosage can be safely applied, and what the results are likely to be. In many instances, of course, these tumors are not available to direct irradiation and therefore we are handicapped to start with. Some of these tumors that he showed here on the anterior pillar could be treated more advantageously and with better results if they were available to direct irradiation, such as the squamous cell tumors that occur on the lower lip. We are, of course, limited by the vital structures around the tumor so that we cannot always apply the dose that we wish, and in some instances we cannot apply it at right angles. We attempt, of course, with small limiting tubes, to get the radiation in and to shield the surrounding structures but, as we all know, that is a very difficult procedure in many cases.

I think the authors are correct in calling tumors in various parts of the body epitheliomas. You can broadly use an anatomical and a pathological description, and, by combining those two, can obtain a better classification.

THE EFFECT OF ROENTGEN IRRADIATION ON EPIPHYSEAL GROWTH

I. EXPERIMENTAL STUDIES UPON THE ALBINO RAT*

By JOSEPH S. BARR, M.D., JAMES R. LINGLEY, M.D., *and* EDWARD A. GALL, M.D.

From the Departments of Orthopedic Surgery, Roentgenology, and Pathology and Bacteriology, Massachusetts General Hospital

BOSTON, MASSACHUSETTS

IN THE course of an earlier investigation[6] it was shown that the growing epiphyseal plate of the albino rat was very markedly sensitive to roentgen irradiation. It was noted that relatively small doses caused sufficient injury to interfere significantly with the growth process. The apparent specificity of this effect upon epiphyseal cartilage with smaller doses (600–1,800 r) and the absence of associated permanent injury in other structures within the field of treatment (bone, skin and bone marrow) was considered noteworthy.

The present investigation was undertaken to amplify this study and to determine the following points:

1. What dosage produces maximal effect on the epiphyseal plate without permanently damaging juxta-epiphyseal tissues?
2. What is the effect of varying dosages on longitudinal bone growth?
3. Does bone deformity, maldevelopment, or fragility occur after such treatment?

To this end, graded dosages of roentgen rays were applied to the growing epiphyses of albino rats and a series of roentgenographic and histologic studies pursued.

METHODS

One hundred and thirty-three albino rats of the same stock constituted the experimental group. These were subdivided according to age at the time of irradiation into Group I, in which the animals were thirty days old; Group II, ninety days old; and Group III, 180 days old. The purpose of this division was to determine the variability of response, if any, which might result from differences in growth rate at varying ages.

The rats in Group III, 180 days old, had relatively mature skeletons and grew so slowly during the period of observation that accurate measurement of change in bone length was impossible. This group was therefore excluded from final roentgenographic consideration.

All animals were housed in suspended open meshed wire cages and subsisted upon the Sherman BMS diet recommended by Russell.[11] To this, there was added for the purpose of incidental studies 3 per cent by weight of Dutch madder.[1]

Each group contained 3 control animals to whom no radiation was administered. These served merely as direct check controls since considerable material was available from untreated extremities in the treated animals. The age groups were subdivided into treatment groups in each of which were approximately 6 animals. All of the animals in a given treatment group received equal amounts of radiation, the individual group dosages ranging as follows: 665 r, 835 r, 1,000 r, 1,165 r, 1,335 r, 1,500 r and 1,800 r. Each dose was administered at a single sitting to the right hind extremity, the field centering about the knee joint. The apparatus was so arranged that the medial surface of the thigh received the entrance dose and the lateral aspect, the exit dose. The remainder of the body was adequately protected by a lead screen.

Roentgens were measured in air with a Victoreen dosimeter and were derived from a Picker-Waite generator, the qualities of which were as follows: 200 kv. (peak), 20 ma., 24 cm. distance, 0.25 mm. copper plus 1.0 mm. aluminum filtration, intensity 203 r per minute, copper half-value layer 0.75 mm.

Animals were immobilized for irradiation by strapping with adhesive tape and an Ace band-

* Aided by a grant from the National Foundation for Infantile Paralysis, Inc.

aged to a Y-shaped plywood board, the hind extremities being abducted upon the divergent arms of the Y. Teleroentgenograms were taken within a few days before irradiation and again upon the day on which the animals were sacrificed. The rats were sacrificed by decapitation at intervals ranging from one to thirty-six weeks after irradiation, the schedule being so arranged that a period of four to six weeks usually intervened between the sacrifice of subjects from the same treatment groups.

Material for histologic study was chosen as follows:

(*a*) Two sections of skin within the area traversed by the roentgen-ray beam, one from the lateral and one from the medial aspect of the lower end of the thigh. The lateral specimen included subcutaneous tissue and both superficial and deep musculature, the medial extended through the fatty panniculus only. In a few instances lymph nodes were included.

(*b*) The knee joint was then exposed and a fragment of infrapatellar synovia excised.

(*c*) The femur was disarticulated, freed of investing soft tissues, and the lower one-half split longitudinally between the condyles. Sections thus included metaphyseal bone, epiphyseal plate, epiphysis and articular surface.

(*d*) From the metaphyseal end of the femoral shaft a portion of marrow was removed with a blunt probe and deposited upon a small piece of filter paper.

Soft tissues were all fixed in Zenker's fluid with acetic acid and paraffin sections were stained with phloxine-methylene blue. Bone was fixed in Bouin's solution, decalcified with 5 per cent nitric acid in alcohol, and stained with hematoxylin-eosin.

Sections from each of the aforementioned areas were studied in order to establish the presence, if any, of injurious effects of irradiation and to grade these according to the degree of severity of the lesion. Since detailed histologic data have been described elsewhere,[6,7,9] the observations are recorded in comparatively brief form. Attention was directed primarily at the determination of that amount of roentgen irradiation which would effectively impede activity of the epiphyseal plate but would not interfere with the integrity of adjacent or covering structures.

OBSERVATIONS

Skin and Subcutaneous Tissue. With the amount of irradiation utilized in these experiments only minimal cutaneous reactions are produced. No evidence of permanent alteration of structure is elicited. Doses up to 1,165 r cause only slight vascular congestion (one to four weeks), minor degrees of keratosis (three to six weeks), and scanty infiltration of the corium with small numbers of lymphocytes and monocytes (one to four weeks). With 1,335 r or more these lesions are increased slightly in prominence and in addition an occasional hair follicle exhibits loss of sheath stratification, epithelial degeneration and epilation (two to five weeks). These changes never attain significant proportions and after the tenth to fourteenth week no residual abnormality can be detected. Subcutaneous tissue, blood vessels, sebaceous glands and skeletal muscle remain unaffected. In lymph nodes included in these sections a few show excessive numbers of phagocytic cells within their sinuses, but they are otherwise not remarkable.

Sections taken from the medial aspect of the thigh are histologically identical with those from the outer side with dosages of 1,165 r or less. Larger amounts of irradiation cause a slightly greater degree of round cell infiltration and hair follicle degeneration on the inner surface of the thigh (the area directly subjected to the roentgen rays). Such lesions are focal, however, and subsequent epilation is never sufficient to permit microscopic recognition. Small clusters of lymphocytes and a few stunted hair follicles persist up to twenty-two to thirty weeks after irradiation but after this period complete re-establishment of the normal structure occurs. Sweat glands, present only on the inner surface of the thigh, are apparently unaffected by the doses applied.

Bone Marrow. The results of the present study are in complete agreement with the observations made upon the series studied in our earlier investigations.[9] There is depletion of approximately one-half or less of the marrow cellular content in the field of irradiation within two to three weeks (Fig. 1). There are no indications of actual necro-

sis; expansion of fat replaces the cells which have disappeared. Regeneration during the

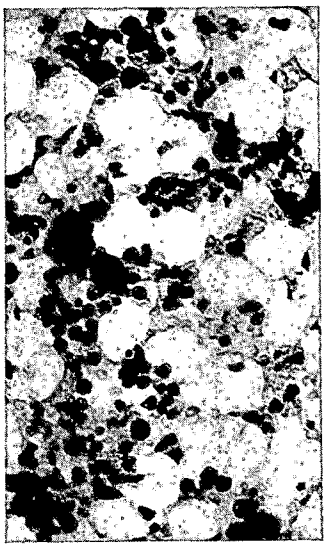


FIG. 1. Femoral bone marrow ten days after irradiation (1,000 r). There is marked depletion of marrow cells with replacement of fat. There is no evidence of necrosis. ×350.

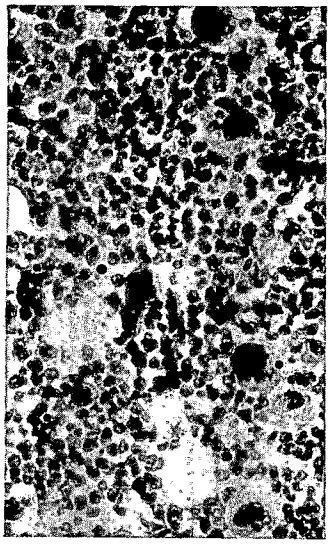


FIG. 2. Femoral bone marrow thirty-five days after irradiation (1,165 r). Marrow cellularity has returned to a level approximating the normal. Few fat vacuoles are evident, and in this area there are 5 megakaryocytes. ×350.

succeeding two to four week period permits the return of cellular volume to a level approximating that preceding treatment (Fig. 2). With dosages up to 1,335 r this constitutes the complete sequence of events. Higher dosages cause a secondary fall which, however, with the amount of irradiation applied in these studies rarely exceeds that of the primary phase. A dosage of 1,500 r causes a permanent reduction to approximately two-thirds of the normal, but higher doses are followed by more marked hypocellularity, hematopoietic elements comprising only one-half to one-fourth of the pretreatment marrow content (Fig. 3). These changes necessarily indicate evidence of significant injury but it should

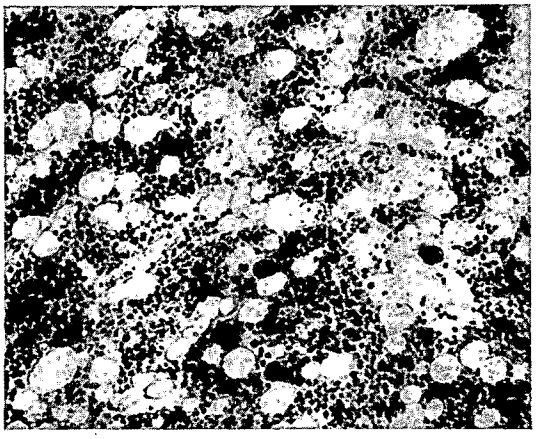


FIG. 3. Femoral bone marrow 190 days after irradiation (1,800 r). Marrow has again been diminished in cellularity and the fat content proportionately increased. ×150.

be remarked that such alterations have been observed only in the highest dose group.

Observations of qualitative effects may be summarized briefly. Primary diminution of marrow content is almost wholly the result of a sharp fall in the number of normoblasts, elements constituting approximately one-half of the nucleated components of normal marrow. Apparent regeneration of these cells contributes to the re-establishment of marrow bulk during the second to fourth week following dosages of 665 to 1,165 r. Animals subjected to greater amounts of irradiation reveal very slight normoblastic regeneration, the secondary rise resulting mainly from an absolute in-

crease in the number of polymorphonuclears. In these rats, subsequent to the attainment of the peak of regeneration, the relative numbers of nucleated red cells continue to diminish progressively, so that in later specimens, mature granulocytes constitute the great majority of marrow cells.

Despite the variation in cell content there is no evidence of abnormality of the fatty marrow (Fig. 3). This tissue merely exhibits a compensatory increase during the periods of hypocellularity. Neither fibrosis, edema, hemosiderosis, nor blood vessel abnormality is detected. It is reasonable to conclude, therefore, that with the exception of blood forming cells no significant injury is sustained by any of the mesenchymal and nutritional elements comprising the marrow

Synovia. The synovia in the region studied normally consists of fibrofatty tissue with only moderate vascularization. Overlying this stroma synovial cells are sparse and flattened in appearance. A rare phagocytic cell is observed in the subsynovial tissue.

Irradiation with 1,165 r or less causes no detectable variation from the normal. Dosages of 1,335 and 1,500 r apparently cause focal thickening of the synovial layer without particular evidence of intrinsic damage. In such regions synovial cells are somewhat more cuboidal in shape and very occasionally form two or three superimposed layers. Monocytes and lymphoid cells are slightly increased in numbers in the subsynovial region but are never very abundant. No evidence of necrosis or unusual proliferative activity is noted (Fig. 4). With 1,800 r single clusters of monocytes assuming the appearance of epithelioid cells are observed in a few specimens. These are never associated with the faintest suggestion of caseation or giant cell formation.

The Epiphyseal Plate. The data recorded by Dawson[3] and our own control series have shown that epiphyseal plate activity in rats in both proximal tibia and distal femur is continuous throughout the entire age period studied in this investigation. Maximal ages attained in the youngest and oldest groups were 300 and 450 days respectively. It was found, however, that the rate of growth could not be predicted on

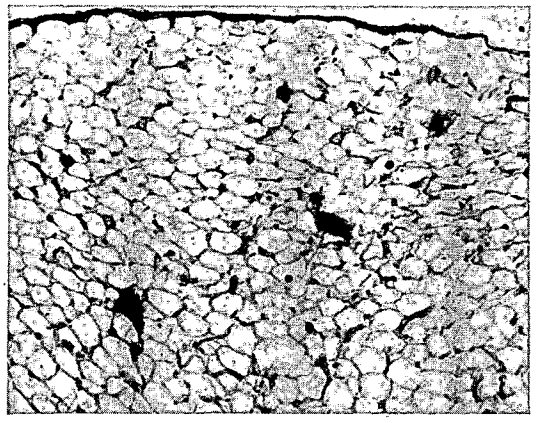


FIG. 4. Infrapatellar fat pad 100 days after irradiation (1,800 r). The synovial surface is intact and the subsynovial fat normal in appearance. ×140.

the basis of the morphologic structure alone. In older animals the cartilage of the epiphyseal plate proper was histologically indistinguishable from that found in the youngest rats. In spite of this the rate of growth was found by roentgenographic studies to diminish slowly up to the nineteenth to twenty-fifth week of life and at this point to exhibit a sharp drop in rate. As a result the increase in length of the tibia in the ninety day old control group was considerably less than in the thirty day old rats over a given period and the rate of growth in the 180 day animals so slow that roentgenographic measurements of length increment were made with difficulty.

In appreciating histologic lesions the morphologic criteria for the normal rat epiphysis as described by Dodds and Cameron[4] have been adopted (Fig. 5). Earlier observations were confirmed and it was noted that the extent of cartilaginous alteration was roughly proportionate to the amount of irradiation administered.

Evidences of injury became apparent within a week after irradiation. These are moderately severe after 665 r and very severe with higher doses, although the

degree mounts progressively with the intensity of treatment. Lesser changes are exemplified by swelling of the chondrocytes,

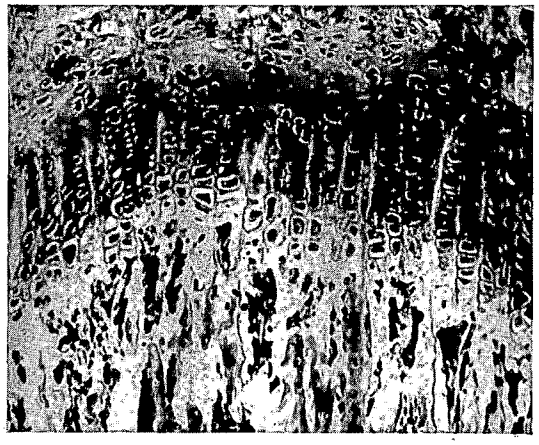


FIG. 5. Lower femoral epiphyseal plate in a normal, untreated, thirty day old rat. Regular columns of active chondrocytes are arranged parallel with the long axis of the bone. Deposits of new bone may be seen along the lowermost portions of the cartilaginous trabeculae. ×150.

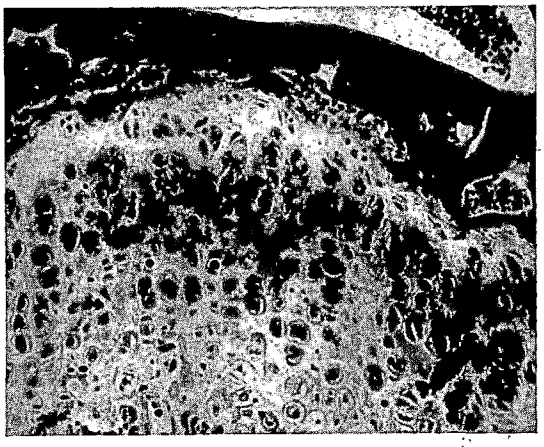


FIG. 6. Epiphyseal plate fourteen days after irradiation (1,165 r). Although the columnar structure persists, the columns are irregular and component chondrocytes are swollen and in many instances pyknotic. Cartilage matrix is mottled in appearance. ×150.

irregularity of columns and variation in staining power of the matrix (Fig. 6). Rats receiving 835 to 1,165 r exhibit progressive disruption of chondrocytic columns, mottling of the matrix and vacant lacunae. Interference with growth is manifested by stunting and ultimate disappearance of primary calcified trabeculae and the development of a subepiphyseal osseous plate (Fig. 7). The latter presumably results from the continued function of apparently unaffected osteoblasts in the absence of the calcified cartilage framework ordinarily available.

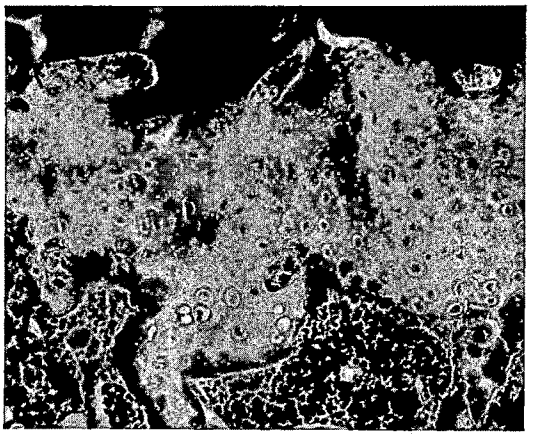


FIG. 7. Epiphyseal plate 184 days after irradiation (1,165 r). Columnar arrangement is completely disrupted and cartilage cells are swollen and varied in size. A thin plate of bone has been deposited along the metaphyseal margin of the epiphysis and calcified cartilaginous trabeculae are no longer evident. ×140.

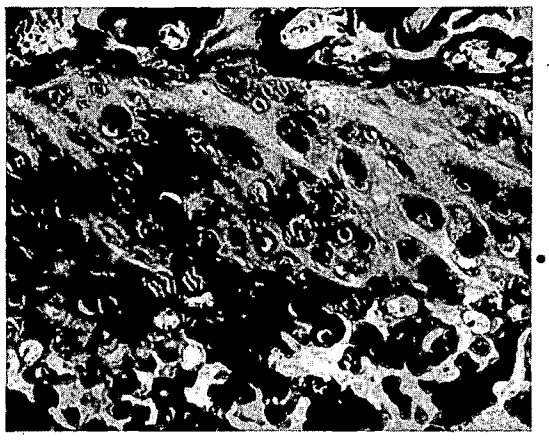


FIG. 8. Severely damaged epiphyseal plate seventy-six days after irradiation (1,800 r). Chondrocytes are disarranged and obviously degenerated. The matrix is frayed and crumbly in appearance. A dark staining layer of subepiphyseal bone may be noted. ×140.

Submaximal to maximal lesions are evident with dosages of 1,335 to 1,800 r and the degree of injury is considerably greater in these groups than in the 665 to 1,165 r range. The epiphyseal cartilage plate is crumbled in appearance, markedly irregular in thickness, and in a few instances, narrow, bony strands pierce the matrix joining the epiphyseal with the metaphyseal plates. These changes unquestionably prevent any significant contribution on the part of the cartilage to further bone growth (Fig. 8).

From the histologic aspect the character of the lesion produced is the same in all age groups.

Evidence of re-establishment of normal histologic structure in even the minimally deranged cartilage is not elicited. In a few instances as might be expected more commonly among the youngest animals, rather scanty apparent reactivation of cartilage cells occurs. This phenomenon, rarely appearing before the sixtieth post-treatment day, is manifested by the development of circumscribed clusters of viable chondrocytes which are normal in appearance but not in distribution. These are aggregated into spherical masses surrounded by thin zones of deeply basophilic matrix. The masses never exceed the size of a single high power field and lack normal orientation to the long axis of the bone. For these reasons they would seem incapable of contributing to the longitudinal growth process and their rarity precludes the development of recognizable deformity. In rare instances such reactivation is associated with a certain degree of orientation. Short columns of cartilage cells are observed growing parallel with the long axis of the shaft. Between the columns is a variable amount of normal matrix. Growth in these foci evidently permits their separation from the degenerated cartilage and sclerotic subchondral plate but the amount of displacement is never of significant extent.

Except for the bony plate formed in the region ordinarily occupied by primary calcified trabeculae no apparent variation from the normal occurs in osseous tissue. Cortical bone retains its usual thickness and compactness in the areas treated and since no deformity developed it is reasonable to assume that its durability is unaffected. Endosteum, periosteum and submetaphyseal trabeculae retain their histological integrity.

Articular Cartilage. By comparison with the epiphyseal plate, articular cartilage exhibits a considerable degree of immunity to roentgen irradiation. Despite the presence of profound disarrangement in the cartilage of the epiphyseal plate, articular surfaces in the immediate vicinity and unquestionably in the path of the roentgen beam are perfectly smooth, obviously functionally unimpaired and show minor intrinsic lesions which are readily matched in control joints (Fig. 9). The length of the experiments was sufficient to permit the development of degenerative joint processes secondary to the altered state of the epiphysis. However, in order to exclude with certainty the possibility of such sequelae further studies relating to the effect of greater weight bearing and activity in such treated joints are in progress.[2]

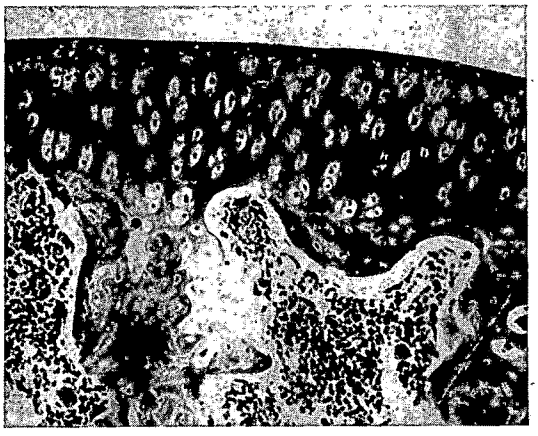


FIG. 9. Femoral articular cartilage seventy-six days after irradiation (1,800 r). Despite severe degenerative changes caused by this dosage in cartilage of the epiphyseal plate, the articular surface is smooth, the chondrocytes visible, and the matrix homogeneous in structure. ×140.

Roentgen Findings. Teleroentgenograms of both lower extremities before treatment

and at varying intervals thereafter show no appreciable change in the architecture of the treated bones following dosages up to 1,165 r. Those tibiae and femora receiving treatment in excess of 1,165 r, however, frequently show a zone of increased density in the metaphyseal region with definite local irregularity of the trabecular structure (Fig. 10).



FIG. 10. Roentgenogram of the irradiated and unirradiated legs of the rats sixteen weeks after a single dose of 1,200 r. Note the difference in length of the tibiae and the zones of increased calcium deposit about the epiphyseal lines of the irradiated knee.

Fracture occurred in only one instance. This was found to be in the mid-shaft in an area which was not exposed to irradiation and could be explained adequately by trauma sustained in the handling of the animal. It was believed that the irradiation had nothing to do with its occurrence.

DISCUSSION

This investigation was motivated initially by the possibility of a practical use for the known radiosensitivity of the epiphyseal plate. Shortening of as much as 4 inches may occur in a leg paralyzed by anterior poliomyelitis. If the treatment of the shortening is delayed until full growth is attained it is necessary to resort to leg lengthening or leg shortening operations. During the period of active growth it is possible to cause premature arrest of epiphyseal growth by epiphyseodesis (Phemister[10]). This procedure carries with it some risk of wound infection, induced deformity and other surgical complications.

The substitution of roentgen irradiation as a means of limitation of the growth of an unaffected limb might conceivably offer advantages (Judy[8]). It would be necessary, however, to demonstrate that no permanent injury would be produced in juxtaepiphyseal structures; that dosages might be so minimized that bone deformity, maldevelopment or fragility would not result; and that a reasonably constant interference with normal growth from the epiphyseal plate could be established.

Interest in this study has therefore been directed fundamentally at these features and accordingly it was shown that treatment with 1,165 to 1,335 r of roentgen rays at 200 kv. was sufficient to cause major interference with epiphyseal activity in the albino rat. Doses between 665 and 1,165 r caused significant but less marked retardation of longitudinal growth.

Measurements of the treated and untreated tibiae before and at various intervals after irradiation demonstrated a definite retardation in growth of the treated bone as compared with the normal growth of the untreated tibia of the opposite leg. Since the activity of the upper tibial epiphyseal plate paralleled that of the lower femoral region[3] and since this bone was more readily susceptible to accurate roentgenography than the femur, it was believed advisable to use it for measurement rather than the femur from which histologic studies were made. Even the lowest dosage used, namely 665 r, was effective in producing definite growth retardation (Tables I and II). The amount of retardation (calcu-

TABLE I

MEASUREMENTS OF TIBIAE FOLLOWING IRRADIATION OF THIRTY DAY OLD RATS

Dosage in Roentgens	Duration of Experiments in Weeks	Untreated Tibiae, Length in cm.		Treated Tibiae, Length in cm.		Length Increment in cm.			Percentage Retardation c/a
		Before	After	Before	After	Untreated a	Treated b	Difference c	
865	10	2.5	3.3	2.5	3.2	0.8	0.7	0.1	12.5
	16	2.3	3.5	2.3	3.3	1.2	1.0	0.2	16.6
	23	2.3	3.7	2.3	3.4	1.4	1.1	0.3	21.5
	29	2.5	4.2	2.5	3.9	1.7	1.4	0.3	17.6
835	7	2.6	3.6	2.6	3.4	1.0	0.8	0.2	20.0
	13	2.7	3.9	2.7	3.7	1.2	1.0	0.2	16.6
	26	2.6	4.0	2.6	3.6	1.4	1.0	0.4	28.5
	32	2.5	3.7	2.5	3.3	1.2	0.8	0.4	33.3
	36	2.5	4.1	2.5	3.8	1.6	1.3	0.3	18.7
1000	8	2.3	3.2	2.3	2.9	0.9	0.6	0.3	33.3
	10	2.5	3.8	2.5	3.2	1.3	0.7	0.5	38.4
	16	2.4	4.1	2.4	3.6	1.7	1.2	0.5	29.4
	22	2.4	4.0	2.4	3.6	1.6	1.2	0.4	25.0
	29	2.6	4.2	2.6	3.6	1.6	1.0	0.6	37.5
	35	2.5	4.1	2.5	3.5	1.6	1.0	0.6	37.5
1165	1	2.7	2.7	2.7	2.7	0.0	0.0	0.0	0.0
	7	2.5	3.2	2.5	3.0	0.7	0.5	0.2	28.5
	13	2.6	3.9	2.6	3.2	1.3	0.6	0.7	53.8
	15	2.4	3.6	2.4	3.1	1.2	0.7	0.5	41.7
	19	2.6	3.9	2.6	3.3	1.3	0.7	0.6	46.2
	32	2.6	4.0	2.6	3.3	1.4	0.7	0.7	50.0
1335	3	2.4	2.8	2.4	2.8	0.4	0.4	0.0	0.0
	16	2.6	3.9	2.6	3.8	1.3	1.2	0.1	7.7
	19	3.2	4.0	3.2	3.5	0.8	0.3	0.5	62.5
	28	2.3	3.9	2.5	3.9	1.4	1.4	0.0	0.0*
1500	3	2.5	2.6	2.5	2.6	0.1	0.1	0.0	0.0
	7	2.7	3.3	2.7	3.0	0.6	0.3	0.3	50.0
	13	2.7	4.0	2.7	3.0	1.3	0.3	1.0	76.9
	19	2.6	4.0	2.6	3.2	1.4	0.6	0.8	57.1
	25	2.5	4.0	2.5	3.1	1.5	0.6	0.9	60.0
	31	2.5	3.9	2.5	3.0	1.4	0.5	0.9	64.3
1800	1	2.9	2.9	2.9	2.9	0.0	0.0	0.0	0.0
	7	2.4	3.4	2.4	2.9	1.0	0.5	0.5	50.0
	13	2.4	3.8	2.4	3.0	1.4	0.6	0.8	57.1
	26	2.6	3.5	2.6	2.8	0.9	0.2	0.7	77.7
	32	3.5	4.2	3.5	3.7	0.7	0.2	0.5	71.4

* Only 2 animals in the entire series showed no evidence of growth retardation after a sufficient interval following irradiation. It is possible that these animals moved sufficiently during treatment so that the knee did not receive the expected dosage. They are excluded from Table III.

lated in percentage of the normal growth as determined in the untreated extremity) increased roughly in proportion to the dosage used (Fig. 11). There was some individual variation in this regard, however; a few animals showed a proportionately

TABLE II

MEASUREMENTS OF TIBIAE FOLLOWING IRRADIATION OF NINETY DAY OLD RATS

Dosage in Roentgens	Duration of Experiments in Weeks	Untreated Tibiae Length in cm.		Treated Tibiae Length in cm.		Length increment in cm.			Percentage Retardation c/a
		Before	After	Before	After	Untreated a	Treated b	Difference c	
665	5	3.3	3.7	3.3	3.7	0.4	0.4	0.0	0.0
	11	3.3	4.0	3.3	3.8	0.7	0.5	0.2	28.5
	17	3.1	4.0	3.1	3.8	0.9	0.7	0.2	22.2
	30	3.1	4.1	3.1	3.9	1.0	0.8	0.2	20.0
	36	3.1	4.1	3.1	3.8	1.0	0.7	0 3	30.0
835	2	3.1	3.5	3.1	3.5	0.4	0.4	0.0	0.0
	8	3.2	3.8	3.2	3.6	0.6	0.4	0.2	33.3
	14	3.3	4.0	3.3	3.9	0.7	0.6	0.1	14.3
	20	3.2	3.9	3.2	3.7	0.7	0.5	0.2	28.5
1000	.5	3.1	3.6	3.1	3.4	0.5	0.3	0.2	40.0
	11	3.1	3.7	3.2	fract.	0.6			
	17	3.2	3.9	3.2	3.5	0.7	0.5	0.2	28.5
	23	3.2	3.8	3.2	3.6	0.6	0.4	0.2	33.3
	36	3.1	4.2	3.1	4.0	1.1	0.9	0.2	18.2
1165	1	3.6	3.7	3.6	3.7	0.1	0.1	0.0	0.0
	8	3.4	3.9	3.4	3.6	0.5	0.4	0.1	20.0
	14	3.4	3.9	3.4	3.5	0.5	0.1	0.4	80.0
	20	3.6	4.0	3.6	3.8	0.4	0.2	0.2	50.0
	26	3.4	4.1	3.4	3.8	0.7	0.4	0.3	42.9
	33	3.2	4.0	3.2	3.6	0.8	0.4	0.4	50.0
1335	5	3.1	3.6	3.1	3.4	0.5	0.3	0.2	40.0
	11	3.1	3.7	3.1	3.4	0.6	0.3	0.3	50.0
	17	3.4	4.1	3.4	3.8	0.7	0.4	0.3	42.9
	36	3.2	3.9	3.2	3.5	0.7	0.3	0.4	57.1
1500	2	3.1	3.5	3.1	3.4	0.4	0.3	0.1	25.0
	8	3.1	3.8	3.1	3.4	0.7	0.3	0.4	57.1
	14	3.2	3.9	3.2	3.5	0.7	0.3	0.4	57.1
	20	3.3	4.0	3.3	3.6	0.7	0.3	0.4	57.1
	26	3.3	3.7	3.3	3.7	0.4	0.4	0.0	0.0*
	32	3.7	4.3	3.7	3.8	0.6	0.1	0.5	83.3
1800	2	3.0	3.3	3.0	3.1	0.3	0.1	0.2	66.6
	8	3.3	3.8	3.3	3.6	0.5	0.3	0.2	40.0
	14	3.2	4.2	3.2	3.6	1.0	0.4	0.6	60.0
	21	3.2	4.1	3.2	3.9	0.9	0.7	0.2	22.2
	27	3.2	4.0	3.2	3.4	0.8	0.2	0.6	75.0
	33	3.3	4.2	3.3	3.7	0.9	0.4	0.5	55.5

* Only 2 animals in the entire series showed no evidence of growth retardation after a sufficient interval following irradiation. It is possible that these animals moved sufficiently during treatment so that the knee did not receive the expected dosage. They are excluded from Table III.

greater amount of retardation than others given similar dosage. The average percentage growth retardation in 56 animals sacrificed eight or more weeks after irradiation is given in Table III. This interval (eight weeks) was chosen since the major

TABLE III

AVERAGE PERCENTAGE RETARDATION OF TIBIAL GROWTH IN FIFTY-SIX ANIMALS SACRIFICED EIGHT OR MORE WEEKS AFTER IRRADIATION

Dosage in Roentgens	30 day old		90 day old		30 and 90 day groups	
	No.	Percentage Retardation	No.	Percentage Retardation	No.	Percentage Retardation
665	4	17.0	4	25.2	8	21.1
835	4	24.3	3	25.4	7	24.7
1000	6	33.9	3	26.7	9	31.2
1165	4	47.9	5	48.6	9	48.3
1335	2	35.1	3	50.0	5	44.0
1500	4	64.6	4	63.6	8	64.1
1800	3	68.7	5	50.5	8	57.4

portion of retarding effects of roentgen irradiation on growth was attained in all instances before this time. It will be noted from Tables I and II that the maximal percentage of retardation was about 60 to 80 per cent. The remaining 20 to 40 per cent of growth increment which occurred in all the treated extremities was undoubtedly due in large part to growth from the distal tibial epiphyseal plate which received no irradiation.

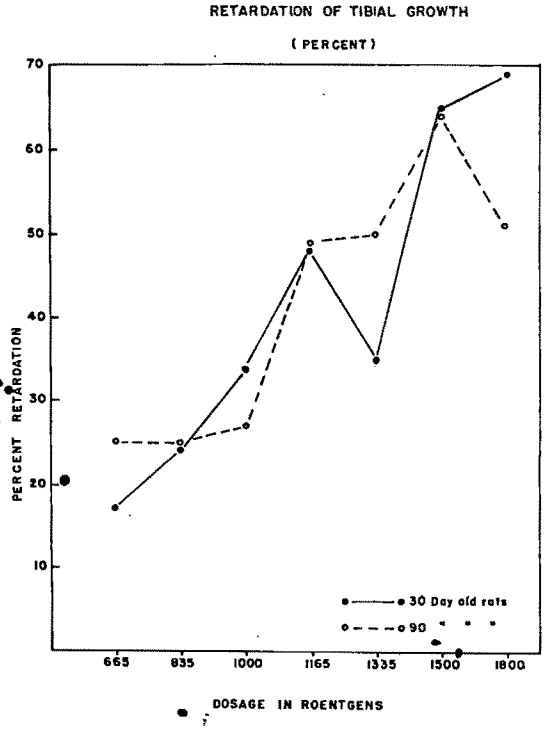


FIG. 11

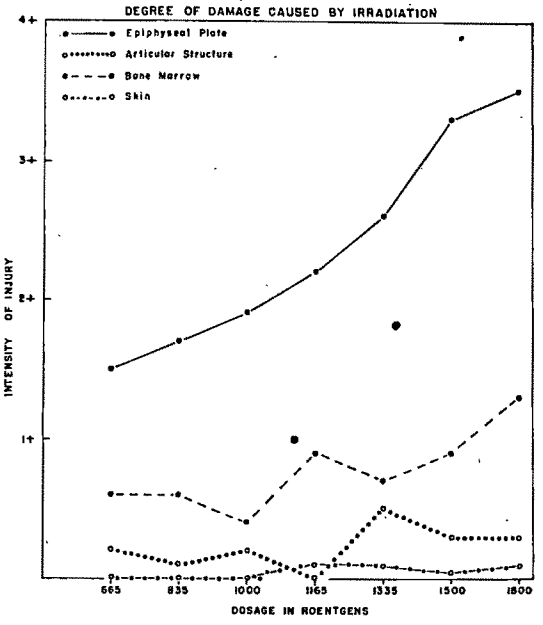


FIG. 12

The ultimate disparity in lengths of the treated and untreated tibiae, as one might expect, was most marked in those treated at thirty days of age. In the 180 day old animals growth was so slow that, although retardation was observed, its accurate measurement was not possible.

An unexpected finding was the similarity in the percentage retardation with equal doses in the two age groups measured. The younger, more actively growing epiphyseal plate in the thirty day old animal would be expected to suffer greater damage than the more mature and less rapidly growing epiphyseal plate of the ninety day old animal when exposed to the same amount of irradiation. This expectation, however, was not borne out by the results of this study. Although the ultimate difference in length of the treated and untreated extremities was greater in the thirty day old animals, when the retardation was plotted in percentage of normal growth the amount of retardation was found to be the same for both age groups (Fig. 1 and Table III). The amount of damage sustained by the growing

epiphyseal plate by irradiation was dependent on the dosage but not on the age of the animal. The fact is of considerable importance to radiologists in the treatment of various lesions in children when the field of irradiation includes a growing epiphyseal plate.

Sections of skin from both directly (medial) and indirectly (lateral) treated portions of the same extremity revealed no evidence of significant injury with the doses used. The epidermis remained intact, there was no permanent atrophy of skin appendages or sustentative elements, and late sequelae were not encountered. Hematopoietic activity within bone marrow in the field of treatment was not seriously impaired. Interference with the blood forming function in a small area of a long bone in a human subject would have no appreciable influence upon the physiologic capacity of the individual. Marrow and cortical vascular channels exhibited little or no variation from the normal. The effects produced in this series upon all of these structures may therefore be safely considered to have no major clinical significance.

The synovia of the knee joint and the joint relations in general were undisturbed. Although with the higher doses articular cartilage exhibited very minor focal areas of degeneration, these were likewise observed in many untreated limbs. They were, therefore, probably of slight significance. Certainly the frequency with which they appeared in those rats receiving 1,165 r or less was not greater than that observed normally.

It is of primary importance to determine conclusively whether or not delayed degenerative changes might be precipitated by either the direct effect of the irradiation upon joint structures or as the result of secondary change related to altered bone growth. These detrimental features have not appeared within a period of nine months after irradiation, an interval which may be considered to represent approximately one-fourth of the rat's normal life span. In order to insure against their production in human subjects similarly treated, however, additional experiments are at present in progress. In these, larger animals (dogs) are being employed and it is planned to observe them for a considerable period after epiphyseal fusion has become completed. It is necessary to state here that the first dog sacrificed recently has shown histologic evidence of injury to the cells of the articular cartilage although no grossly detectable damage appeared. It is our intention to refrain from applying our results clinically until these possibilities have been safely excluded.

SUMMARY AND CONCLUSIONS

A group of thirty, ninety and 180 day old albino rats were subjected to roentgen irradiation of one knee joint and the resultant changes studied histologically and roentgenographically. The epiphyseal plate is a very radiosensitive tissue. Doses of 665 to 1,165 r produced moderately severe histological changes while doses of 1,335 to 1,800 r caused very severe injury as evidenced by disruption of the cartilage cell columns and destruction of chondrocytes. There was no evidence indicating stimulation and only inconsequential evidence of regeneration of epiphyseal cartilage. Other tissues in the treated area—skin, subcutaneous tissue, muscle, synovia and articular cartilage—showed insignificant changes of a transitory nature (Fig. 2). The hematopoietic elements of the bone marrow in the treatment field were diminished but this local effect seemed to be of little significance to the organism as a whole. No degenerative or traumatic changes were noted in the treated joints even after nine months' observation.

Careful measurement of longitudinal growth of the tibia after irradiation showed that the doses used (665 to 1,800 r) all produced retardation of growth and that the retardation varied roughly proportionately to the irradiation administered. The larger doses 1,335 to 1,800 r seemed to produce essentially complete arrest of growth of the treated epiphysis.

REFERENCES

1. BARR, J. S., LINGLEY, J. R., and GALL, E. A. Unpublished studies.
2. BARR, J. S., LINGLEY, J. R., and GALL, E. A. Control of epiphyseal growth by roentgen irradiation. II. Experimental studies upon the dog. In progress.
3. DAWSON, A. B. Age order of epiphyseal union of long bones of the albino rat. *Anat. Rec.*, 1925, *31*, 1.
4. DODDS, G. S., and CAMERON, H. C. Studies on experimental rickets in rats. I. Structural modifications of the epiphyseal cartilages in tibia and other bones. *Am. J. Anat.*, 1934, *55*, 135–165.
5. ENGEL, D. Experiments on the production of spinal deformities by radium. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *42*, 217–234.
6. GALL, E. A., LINGLEY, J. R., and HILCKEN, J. A. Comparative experimental studies of 200 kilovolt and 1000 kilovolt roentgen rays. I. Biological effects on the epiphysis of the albino rat. *Am. J. Path.*, 1940, *16*, 605–618.
7. GALL, E. A., LINGLEY, J. R., and HILCKEN, J. A. Comparative experimental studies of 200 kilovolt and 1000 kilovolt roentgen rays. III. Biologic effect on the skin of the albino rat. *Am. J. Path.*, 1941, *17*, 319–334.
8. JUDY, W. S. An attempt to correct asymmetry in leg length by roentgen irradiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 237–240.
9. LINGLEY, J. R., GALL, E. A., and HILCKEN, J. A. Comparative experimental studies of 200 kilovolt and 1000 kilovolt roentgen rays. II. Biological effects on the bone marrow of the albino rat. *Am. J. Path.*, 1940, *16*, 845–854.
10. PHEMISTER, D. B. Operative arrestment of longitudinal growth of bones in treatment of deformities. *J. Bone & Joint Surg.*, 1933, *15*, 1–15.
11. RUSSELL, W. C. Addition of raw beef or meat scrap to a wheat-milk diet. *J. Nutrition*, 1932, *5*, 347–357.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR

Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.

Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, to be announced.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo.; *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, to be announced.

EDITORIAL

THE OBTURATOR SIGN IN THE EARLY ROENTGEN DIAGNOSIS OF SEPTIC ARTHRITIS OF THE HIP

THE importance of the psoas muscle shadow as a diagnostic aid in roentgenographic examinations in a suspected psoas abscess, a perinephric abscess, or retroperitoneal tumor is well known to all roentgenologists. However, the importance of soft tissue shadows in the pelvic area as seen in the anteroposterior projection in roentgenograms had been overlooked as an aid in the differential diagnosis until Hefke and Turner,[1] in a recent article, pointed out the importance of the soft tissue shadow just medial to the acetabulum on the inner aspect of the pelvis as an aid in the roentgen diagnosis of septic arthritis and in tuberculosis of the hip.

The border of this soft tissue shadow, as described by Hefke and Turner, ordinarily starts from a point lateral to and below the lower pole of the sacroiliac joint, follows the line of the pelvic inlet downward over the acetabulum, and disappears behind the upper ramus of the pubis. This shadow in normal children measures from 2 to 8 millimeters at its widest point, and usually the shadow on one side corresponds in width to the shadow on the other. There may, however, be a minimal difference in the width of these shadows in normal individuals.

In order to determine the exact structure which caused this shadow, Hefke and Turner made dissections on postmortem specimens and by the use of curved wires paced along the inner border of the psoas, and an anteroposterior roentgenogram, they were able to demonstrate that the psoas muscle did not correspond to the shadow described. Therefore the psoas was removed and another roentgenogram was obtained, and by a process of elimination they finally determined that the obturator internus muscle is definitely proved to be the substratum of the shadow.

These authors point out that it is well known that the tendon of the obturator passes immediately adjacent to the capsule of the hip and extension of the inflammatory process may well lead to a roentgenographically visible swelling of the obturator muscle.

The obturator sign, as described by Hefke and Turner, consists in a widening and a change in the contour of the normal obturator shadow. This widening may be very slight to very marked, and four gradations, from 1 to 4, were arbitrarily chosen as a basis for classification of their cases. Grade 2 was considered to include those cases in which the shadow was approximately twice the normal width; Grade 4, more than four times the normal, and Grades 1 and 3 were placed correspondingly. In the interpretation of changes in the obturator muscle the shadows of the uninvolved hip area were taken as normal.

In a small number of cases it was noted that the obturator shadow was obscured, and after an analysis of their cases they came to the conclusion that the obscured obturator shadow is a positive finding indicative of a pathological condition of the hip joint.

The technique for routine anteroposterior roentgenograms of the pelvis was followed in their studies. No special advantage had been shown by using soft tissue technique. They point out the fact, however, which is only too obvious, that the pelvis must be level or one obturator may be thrown into higher relief than the other

[1] Hefke, H. W., and Turner, V. C. The obturator sign as the earliest roentgenographic sign in the diagnosis of septic arthritis and tuberculosis of the hip. *J. Bone & Joint Surg.*, 1942, *24*, 857–869.

one, which could bring about some confusion in the interpretation of the soft tissue shadow. In a number of their cases they found it of advantage to obtain an anteroposterior view of the pelvis with the hips in marked abduction, flexion to 90 degrees, and marked external rotation—the so-called "frog position" frequently used in obtaining lateral views of the hips. This position brings into greater relief the obturator shadow but in an acute septic condition involving the hip such a position may be out of the question because of the intense pain from which the patient suffers.

The importance of a correct diagnosis in septic arthritis of the hip warrants the use of any method or methods of examination which will help one to arrive at an early diagnosis before the devastating effects of the infection are manifest. In their study of the obturator sign 23 cases of septic arthritis of the hip served as the clinical basis. They found that the obturator sign is of greatest value during the early weeks of hip disease. At the end of the first two weeks it was possible to make a roentgen diagnosis of hip disease in 94 per cent of the cases, whereas using bone and joint changes alone, the diagnosis could have been made in only 25 per cent. The obturator sign was first found positive on the third day, joint changes on the fifth and bone changes on the eighth. Therefore the obturator sign in the experience of these authors is the earliest roentgenographic sign observed in septic arthritis of the hip.

The obturator sign is of less importance in the diagnosis of tuberculosis of the hip as the onset of this condition is so much less sudden and dramatic than septic arthritis, and unfortunately the first roentgenographic examination made in suspected cases of tuberculosis of the hip are delayed for weeks and at times even months after the onset of the initial symptoms.

In an analysis of their group of cases of tuberculosis of the hip they found that the obturator shadow was most frequently obscured, rather than showing a distinct bulging with sharply demarcated border, as is usually observed in cases of septic arthritis of the hip, and it was obvious from their studies that the obturator sign is of no great value in making a diagnosis of early tuberculosis of the hip inasmuch as both the bone and joint changes usually appear earlier and with greater frequency.

In Perthes' disease, in both the early and late stages, they observed no change in the obturator shadow and in slipping of the capital femoral epiphysis there was observed no change in the obturator shadow, and likewise in fractures of the pelvis, ischium, ilium, and femur close to the hip joint no pathologic change was observed in the obturator outline. In osteomyelitis of the pelvis not involving the neighboring hip joint no obturator involvement was noted. Also in soft tissue infection about the thigh with marked inguinal lymphadenopathy they observed no abnormality in the obturator shadow.

It is evident from the studies which Hefke and Turner have carried out that the obturator shadow becomes of the greatest value in the early roentgenographic diagnosis of septic hip disease and it is of utmost importance that this diagnostic sign be not overlooked as it appears to be one of the earliest roentgenographic signs in the diagnosis of septic arthritis of the hip. It is hoped that other observers will pay particular attention to the obturator sign as an additional aid in the roentgenographic diagnosis of septic arthritis of the hip.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, to be announced.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1943, to be announced.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital. Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. L. W. Baird, Scott and White Clinic. Temple, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton Alberta.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secreatry for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

BULLETIN OF THE AMERICAN COLLEGE OF RADIOLOGY

AN OPEN LETTER TO RADIOLOGISTS

The cornerstone of modern medical care is correct diagnosis, and the keystone of correct diagnosis is competent radiology. Competent radiology requires that there be adequate numbers of trained radiologists available both for patients outside hospitals and patients inside hospitals. As far as outside patients are concerned, there are fortunately hundreds of well trained conscientious radiologists in private practice who are doing good work and, as far as can now be told, will continue to do good independent American medical work in the future.

When we turn to the hospital situation the picture is somewhat different. There are hundreds of competent radiologists in American hospitals today, but many of them are *not* conducting their own practices. They have not the right to decide who shall be appointed as technicians and nurses in their departments, they cannot always decide the kind of equipment with which they must operate, and they often cannot decide the extent of the services which they believe they should render to patients, or the fees they should charge for those services. In other words, the departments of radiology are no longer under the direction of the radiologist in many hospitals—they are under the direction of the hospital superintendent.

If this were just a matter of fees or financial reward it might, with the altruistic traditions of the medical profession, well be overlooked. However, it obviously goes beyond that. He who pays the piper calls the tune. Precedents created today, especially in connection with group hospitalization insurance, may be frozen into our medical picture tomorrow.

What then should we do? The first and foremost obligation on every hospital radiologist is to do good medical work and to see that in every manner possible he keeps radiology identified as a medical specialty, as a branch of medicine and not as a branch of hospital work. He should pay as much attention to the organization side of his department as he does to the scientific side. If he is indifferent, or too busy, or too lazy to attend to the organization side he will find that in the eyes of the average layman, the average hospital superintendent, yes and even in the eyes of doctors, he is not in charge of his own department. More and more laymen and physicians are coming to regard radiology as a part of hospital service and not medical care. This is largely our own fault. (We are referring not to one or two large research or diagnostic clinics, but the average private hospital throughout the land.)

Again we ask, what should be done about it? We would suggest that for the sake of the scientific future of radiology in hospitals, as well as for the sake of the rights of the rest of our profession we should not consent to the inclusion of our services in any formally organized hospital insurance scheme. This will require courageous action and constant vigilance. The radiologist cannot always control details of practice as far as ordinary hospital in-patients are concerned. However, when a Blue Cross plan or a health insurance scheme gets started, the radiologist should go to his local county medical society and ask it not to approve any scheme that attempts to provide medical services (whether they be surgery or roentgen ray) as a part of hospitalization benefits. And, if they are already included, seek their exclusion or segregation. The crux of the Blue Cross plan problem is that many Blue Cross plans provide not group hospitalization, but hospitalization plus diagnostic-medical-care and in so providing will inevitably and ultimately control hospital radiology.

Think of it: ten million Americans are now covered by Blue Cross plans. In another decade twenty-five million Americans will be so covered. Instead of having diagnostic radiology benefits as an in-patient, they will be extended to out-patients also. Why? To avoid abuse of hospital beds.

Today, many subscribers *are* being hospitalized *only* because they are entitled to free roentgen-ray services. By offering outpatient roentgen-ray services, the hospital will be able to reduce bed occupancy.

To further reduce hospital costs, more and more radiologists will be hired and fired on the basis of the cheapest salary they will accept and not on their professional qualifications. The caliber of diagnostic medicine will suffer as the caliber of radiology declines.

Therefore, for purely scientific considerations alone, for the welfare of the specialty you have chosen, please awake to the vital necessity of having your service identified as a medical service, especially in Blue Cross plans. The present economic arrangements in medical practice have never come up for formal approval by a county or state medical society. But Blue Cross plans have. Observe that the American Medical Association has never approved a single Blue Cross plan. Why? Because the American Medical Association knows that if the Blue Cross plans can sell radiology today, and secure approval, they can sell surgery and ordinary medical care tomorrow, and demand approval. In no time they could control the entire practice of medicine. A group of laymen or corporations (always "not-for-profit") could dictate how and where medical practice should be conducted in this country.

Let us give group hospitalization our ardent support—when it *is* group hospitalization. There are today many communities, notably Kansas, Missouri, Washington, D. C., Michigan, Florida and California, where radiology is either not sold at all in connection with group hospitalization, or if sold is provided as a medical benefit along with, but not as a part of, hospital service. Checks for medical services are payable to medical men. Therefore, the group hospitalization corporation makes checks for radiology in hospitals payable to medical men. If he is on a salary or percentage basis he merely endorses the check and turns it over to the hospital treasury. If he is on a lease or rental basis he deposits the check to his account as would any other professional man. The importance of the distinction is exquisite. You are urged to ponder this problem and to take action now. You will be appalled to hear that some radiologists in one of our midwestern states have actually requested the local group hospitalization concern to make the checks payable to the hospital and not themselves. What incredible myopia!

Radiologists please awake. Our number one problem is to win the war. Our number two problem is to prevent the destruction of scientific practice and of diagnostic medical care for generations to come. No layman, no Blue Cross director can be expected to understand that radiology is the practice of medicine, and that you as radiologists have any professional rights whatsoever! You have to tell them these things and tell them repeatedly. Just as all freedom loving people have to fight for their freedom at regular intervals, almost every generation, so we, as members of the youngest and most rapidly developing specialty in medicine, have to fight for our own rights, and can proudly do so knowing that we are fighting for the rest of medicine at the same time.

Remember, ignoring entirely your own personal tastes in the matter and your own disregard for income, you should still awaken to the fact that the scientific side of your practice requires that it remain identified as a medical practice and not become a hospital one. To so identify it, you should collect your own fees and request all insurance companies, Blue Cross plans, hospitalization companies, and so forth, to make checks for medical services payable to medical men, that is, checks for radiological services payable to radiologists. And by payment is meant the entire sum and not any artificial division of medicine or surgery into technical and professional. The surgeon performs many technical procedures in his work and yet it would be absurd and destructive of his practice if

it were attempted to divide it into technical and professional. The same applies to radiology. In the words of the American College of Surgeons, each doctor concerned in the care of a patient should give or send directly to the patient a detailed statement showing the charges for services rendered. Your colleagues in private practice do so today. Will you in your hospital practice not seek to do likewise?

L. Henry Garland, M.D., Chairman
Commission on Hospital Standards,
American College of Radiology

STRAY RADIATION IN FLUOROSCOPIC ROOM

As an advisory member for the Committee on Safety and Standards, I wish to make the following supplementary report:

Recent studies of fluoroscopic roentgen-ray units have demonstrated the advisability of calling attention to stray radiation received per week by each occupant of the fluoroscopic room.

It has been found that when the shutters are opened to the limit, in order to cover the fluoroscopic screen near the table top, they will allow radiation to pass beyond the screen when moved away from the table top unless there is an automatic arrangement attached to the movement of the screen to control the opening of the shutters. If the roentgenologist is careful to keep the shutters closed so that the field of radiation is still visible, at all times, there will be no radiation passing beyond the screen. Roentgenologists often have a habit of opening the shutters wide when taking the first look, regardless of the position of the screen.

Considerable stray radiation may be scattered from the diaphragm opening and the patient. If the diaphragm opening is not well protected with lead to the table top, radiation will be scattered to those standing near the table. Lead aprons will absorb this radiation. Tests may be made by all the occupants of the fluoroscopic room by wearing dental films for a week. If the dental films are sufficiently blackened so that it is impossible to read ordinary print through the film, they have probably received more than 0.4 to 0.5 r.

J. L. Weatherwax, *Physicist*

AMERICAN COLLEGE OF PHYSICIANS

The Board of Regents of the American College of Physicians has announced the cancellation of their 1943 Annual Session, which was scheduled to be held in Philadelphia, April 13–16, 1943. This action was taken after thoughtful consideration of all factors involved, including an intimation from the Secretary of War and the Office of Transportation that larger national medical groups should not plan meetings at the time set; a growing difficulty in getting speakers and clinicians of top rank to maintain the usual standards of the program; prospect of greatly reduced attendance, because civilian doctors are faced with too great a burden of teaching and practice already; a decreasing active membership, due to approximately 25 per cent of all doctors being called to active military service. President James E. Paullin announced, however, that all other activities of the College would be pursued with even greater zeal, and that the College would especially promote regional meetings over the country and organize postgraduate seminars in the various military hospitals for doctors in the Armed Forces.

UROLOGY AWARD

The American Urological Association offers an annual award "not to exceed $500" for an essay (or essays) on the result of some specific clinical or laboratory research in Urology. The amount of the prize is based on the merits of the work presented, and if the Committee on Scientific Research deem none of the offerings worthy, no award will be made. Competitors shall be limited to residents in urology in recognized hospitals and to urologists who have been in such specific practice for not more than five years.

Essays must be in the hands of the Secretary, Dr. Thomas D. Moore, 899 Madison Avenue, Memphis, Tennessee, on or before March 1, 1943.

Miley B. Wesson
Chairman, Committee on Scientific Research

AMERICAN BOARD OF RADIOLOGY

The Board of Trustees of the American Board of Radiology has decided to continue examinations during the emergency, and will therefore conduct an examination during April, May or June of 1943. An attempt will be made to hold the examination at a place most convenient to the majority of the candidates.

Those wishing to be examined at the spring examination must have their application on file by March 1, 1943. Address all communications to Dr. B. R. Kirklin, Secretary, American Board of Radiology, Mayo Clinic, Rochester, Minnesota.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

AN X-RAY ATLAS OF SILICOSIS. By Arthur J. Amor, M.D., (Lond.), M. Sc. (Wales), Honorary Physician, Clydach Memorial Hospital; Medical Officer, Mond Nickel Company, Ltd., Swansea. With translation of the Legends into French by Robert E. Horne, M. A. (Wales), Medical Secretary, Mond Nickel Company, Ltd., Swansea. With a foreword by Sir Wilson Jameson, M.A., M.D. (Aberdeen), F.R.C.P., of the Middle Temple, Barrister-at-Law; Dean of the London School of Hygiene and Tropical Medicine. Cloth. Price, $8.00. Pp. 206, with 72 illustrations. Baltimore: Williams & Wilkins Company, 1941.

This Atlas of Silicosis was written to describe the essential roentgenologic features of silicosis for senior medical students, industrial physicians, and those dealing with this type of disease.

The author has described briefly the etiology, pathology, roentgen manifestations, and clinical findings in silicosis and some of the nonspecific pneumoconioses. No effort has been made to go into detail concerning many of the aspects of this subject. He has, however, given sufficient information in the first four chapters to stimulate one to look elsewhere, if one is interested in this subject. The average physician is not familiar with the roentgen findings in a number of these conditions. Therefore, the author has devoted the major portion of his book to illustrating representative chest films and has given the history of these cases in both English and French.

The publishers have selected a very good print for this book, but the paper is very glossy and it is exceedingly difficult to read unless the light is just right. In selecting a calendar of paper for the illustrations the publishers have done an excellent job. Anyone familiar with reproducing the roentgen findings in silicosis is aware of the difficulties. In spite of this the author has been successful in most instances.

EUGENE P. PENDERGRASS

MALIGNANT DISEASE AND ITS TREATMENT BY RADIUM. By Stanford Cade, F.R.C.S., Surgeon, Westminster Hospital, Mount Vernon Hospital, and The Radium Institute; Lecturer in Surgery, Westminster Hospital Medical School; Associate Examiner in Surgery, University of London, etc. Cloth. Price, $18.00. Pp. 1280, with 623 illustrations, many in colour. Baltimore: Williams & Wilkins Company, 1940.

This ambitious volume includes information gained from the treatment of 3,000 cases of malignant disease cared for at Westminster Hospital, Mount Vernon Hospital and elsewhere in England. These patients all received radiation therapy alone or a combination of irradiation and surgery. The first 94 pages deal with the radioactivity of radium and include chapters on mass units, dosimetry and the measurements of plaques by Dr. H. T. Flint, Dr. C. W. Wilson and Dr. L. H. Gray. All doses are expressed in roentgens but unfortunately the difference between x-ray roentgens and gama-ray roentgens is not emphasized. Although a sketchy description of practical dosage calculation is given, the student will find it practically impossible to estimate actual tissue doses from the data provided.

The second section, comprising 180 pages, is entitled "The Biological Effects of Radiation" and deals with radiosensitivity, the mode of action of radiation, the effects of radium on normal and malignant tissues and radiation protection. The effects of over-irradiation of certain portions of the body are described in great detail, but this portion of the volume is incomplete. For instance, no mention is made of over-irradiation of the intestine, which constitutes one of the most important sequelae observed in actual practice.

The remainder of the book is divided into 20 chapters devoted to the clinical picture, pathology and treatment of malignant disease as it appears in the various anatomical locations. The material is well presented and techniques are illustrated so that they can be easily dupli-

cated, but the method of dosage calculation in terms of gamma-ray roentgens is still not clarified. The outstanding contribution of the volume consists of a convincing demonstration of the efficiency of multiple weak, heavily filtered radium needles and capsules used for relatively long periods of time. In no other publication can one find such a wealth of information relative to the indications for the use of this method in the treatment of cancer. This good feature is somewhat marred by the author's preference of the radium bomb for external irradiation, a preference which does not seem to be upheld by his recorded results.

The book is printed on a good grade of paper and the illustrations, many of which are in color, are unusually well done. The pathology and clinical classifications of the various types of cancer are adequately covered and although little American literature is included, an extensive bibliography is given at the end of each chapter. If the alleged superiority of teleradium be discounted this text will be found especially valuable by the radiologist who must work with relatively small amounts of radium.

CHARLES L. MARTIN

THE 1941 YEAR BOOK OF RADIOLOGY. *Diagnosis*, Edited by Charles A. Waters, M.D., Associate in Roentgenology, Johns Hopkins University; Assistant Visiting Roentgenologist, Johns Hopkins Hospital; Associate Editor, Whitmer B. Firor, M.D., Assistant in Roentgenology, Johns Hopkins University; Assistant in Roentgenology, Johns Hopkins Hospital. *Therapeutics*, Edited by Ira I. Kaplan, B.Sc., M.D., Director, Radiation Therapy Department, Bellevue Hospital, New York City; Associate Radiologist, Lenox Hill Hospital, New York City; Clinical Professor of Surgery, New York University Medical College. Cloth. Price, $5.00. Pp. 440, with 486 illustrations. Chicago: Year Book Publishers, Inc., 1941.

The 1941 Year Book of Radiology has been in use for several months and most radiologists are aware of its contents. In view of its widely recognized usefulness it needs hardly more than a routine announcement. Those about to enter on the specialty should know that in this one book is contained more information in condensed form than could be obtained from any other single source or indeed from many more sources than are available to the average physician. In fact 80 scientific publications have been searched by the capable staffs of Drs. Waters and Kaplan with the usual remarkable collection of interesting cases and aids to diagnosis and treatment.

The diagnostic section dealing with the osseous system alone contains so many interesting subjects that it is difficult to select those most interesting. So-called creeping fractures, pseudofractures, infarction of bones, hemangiomas, eosinophilic granulomas of bone, dorsal bunion, anomalies of occiput, axis and atlas are a few of the highlights of the osseous section.

The glandular, respiratory, gastrointestinal, genitourinary and other special divisions of the diagnostic portion contain fully as interesting an array of subjects. The chapter on military roentgenology needs no comment as to its timeliness.

Therapeutics surpasses if possible the high standards of previous years. Treatment of angina pectoris and hypertension, prevention of hearing defects by pharyngeal irradiation, roentgen therapy of glaucoma avoiding enucleation, treatment of bursitis and rheumatic disease, accurate forecasting of irradiation sickness are among the non-malignant conditions contained in Dr. Kaplan's section, and study and treatment of malignant conditions occupies its usual important share of space. As in former years the editorial comments following many of the abstracts aid the younger man in evaluating the facts and conclusions of the original authors and are an invaluable part of the work.

E. WALTER HALL

EPILEPSY AND CEREBRAL LOCALIZATION: A STUDY OF THE MECHANISM, TREATMENT AND PREVENTION OF EPILEPTIC SEIZURES. By Wilder Penfield, Litt. B., M.D. (Johns Hopkins), D. Sc. (Oxon., Princeton), Professor of Neurology and Neurosurgery, McGill University; Director of the Montreal Neurological Institute, and Theodore C. Erickson, M.A., M.Sc., M.D. (Minnesota), Ph.D. (McGill), Formerly Lecturer in Neurosurgery, McGill University; Assistant Surgeon, Montreal Neurological Institute; Now Associate Professor of Surgery, University of Wisconsin. Chapter XIV by Herbert H. Jasper. Chapter XX by M. R. Harrower-Erickson. Cloth. Price, $8.00. Pp. 623, with 163 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

This scholarly volume should perhaps be entitled "Cerebral Localization and Epilepsy." The portion of the book which entitles it to a permanent place in medical literature is the series of excellent case reports illustrating the principles of cortical localization. No such group of well-recorded observations on the results of stimulation and extirpation of various portions of the brain has ever been reported.

The arrangement of the book tends to give the impression that the majority of cases of epilepsy are due to focal lesions susceptible of surgical removal. This impression is strengthened by the inclusion of an account of the relief of seizures by removal of brain tumors. The authors' experience with the control of seizures by surgical means has been unusually favorable —about 40 per cent in carefully selected cases. The authors remark: "Operations for the surgical removal of epileptogenic lesions of the brain, however incompletely developed, already offer a more encouraging and gratifying prospect to the neurosurgeon than does the radical treatment of brain tumors."

Relatively little attention is paid to the subject of cryptogenic or "idiopathic" epilepsy, which enormously outnumbers all other types. From the table on page 22, one would judge that cryptogenic seizures were to be suspected strongly only in the second decade. The proportion of spontaneous improvement is given at 2 per cent; this is lower than the figure given, for example, by Lennox, of 20 per cent. No comparison is given between the results of medical and those of surgical treatment. The authors are wholly skeptical of the value of medical treatment of seizures due to focal lesions, but in other clinics the results of such treatment are excellent.

There are extremely good special chapters on cranial roentgenography, electroencephalography, and of the results of psychological studies.

This book should be in the library of every neurologist, indeed of every physician interested in the important subject of seizures.

TRACY J. PUTNAM

DEPARTMENT OF TECHNIQUE

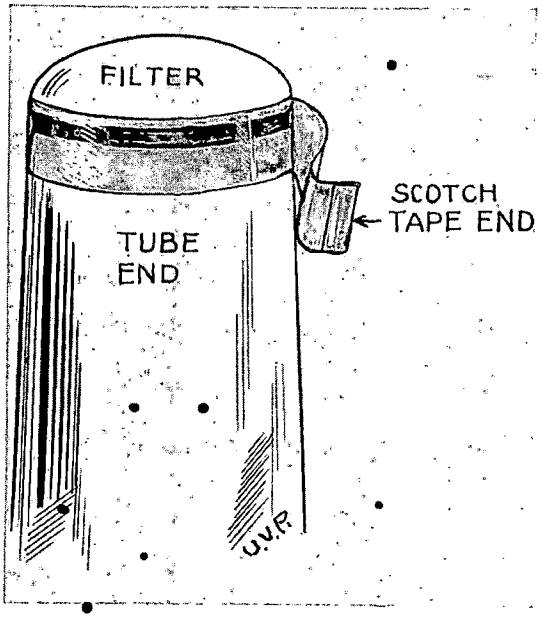
Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

A SIMPLE WAY TO HOLD A FILTER IN PLACE ON CONTACT THERAPY TUBES

By U. V. PORTMANN, M.D.
Cleveland Clinic
CLEVELAND, OHIO

WE HAVE been accustomed to hold a filter in place on the contact therapy tubes (Philips-Metalix) by slipping a finger cot over it and the tube end or to drop the filter into a localizing cone.

There are disadvantages to these methods. The thin rubber cot tears easily. It is becoming difficult to obtain cots of proper size. The filter sometimes gets out of alignment because it is not held securely enough. When an unattached filter is dropped into a localizing cone it may be inverted, which is annoying, and if not discovered will result in decreased dosage from increased distance.



These difficulties may be obviated by adjusting the concavo-convex filter on the tube end and wrapping a single short strip of half or quarter inch scotch cellulose tape around the rim of the filter and tube end as illustrated. This can be done quickly, the filter is held securely, it is clean and cheap. If a sterilized tube end is desirable, the filter may be attached as described, then a cot will slip over it easily. Protected in this way the rubber covered tube end may be immersed in a germicidal solution. It is easier to remove the tape if made longer than the circumference of the tube, then turned back on itself with adhesive surfaces in apposition thus making a small tab to grasp. Adhesive material sticking to the tube may be wiped away with alcohol or benzine.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Abdomen

McNEILL, J. H.: Persimmon phytobezoar with case report 130
SCHINDLER, R., STEINER, P. E., SMITH, W. M., and DAILEY, M. E.: Classification of gastric carcinoma 130
BRUNN, H., and GOLD, R. L.: Surgical problem of chronic gastritis 130
MULLEN, T. F.: Some factors influencing curability of cancer of stomach 131
BIEREN, R. E.: Carcinoma of lower intestinal tract 131
BUIRGE, R. E.: Carcinoma of large intestine .. 132
MACDONALD, D.: Common bile duct peristalsis. 132
FELDMAN, M.: Terminal common bile duct and duodenal papilla 132
ARCE, J.: Hydatid cyst of liver 132

Skeletal System

LACHMAN, E.: Limitations of roentgen diagnosis of fractures 133
RIESENMAN, F. R., and YATER, W. M.: Osteogenesis imperfecta 133
COUCH, J. H., and ROBERTSON, H. F.: Occurrence of postoperative acidosis and pagetoid bone changes in hyperparathyroidism 134
BATTS, M.: Periosteal fibrosarcoma 134
BADGLEY, C. E., and BATTS, M., JR.: Osteogenic sarcoma 135

General

CAMPBELL, D. A.: Carcinoma of upper extremity 135
CAMIEL, M. R., and BOLKER, H.: Carcinoma erysipelatodes 135
SAPHIR, O., and PARKER, M. L.: Metastasis of primary carcinoma of breast 136
BRAUND, R. R., and MARTIN, H. E.: Distant metastasis in cancer of upper respiratory and alimentary tracts 136
LIST, C. F.: Intraspinal epidermoids, dermoids, and dermal sinuses 137
DONHAUSER, J. L., and DE ROUVILLE, W. H.: Multiple myeloma 137
LUTZ, J. F.: Calcinosis universalis 138

ROENTGEN AND RADIUM THERAPY

WALLACE, W. S.: Studies in radiation sickness. II 138
DALAND, E. M.: Radiation damage to tissue and its repair 139
YOUNG, F.: Treatment of persistent recurrent basal cell carcinoma of the face 139
ARBUCKLE, M. F., and STUTSMAN, A. C.: Pharyngeal and laryngo-pharyngeal cancer 139
RHINEHART, D. A., and RHINEHART, B. A.: Protracted roentgen treatment of malignancies particularly of head and face 140
NEW, G. B., and HALLBERG, O. E.: End-results of treatment of malignant tumors of the palate 140
KAMPERMAN, G.: Present status of treatment of gynecological cancer 141

MISCELLANEOUS

HAMES, F.: Accurate placement of radon seed by suture method 141
ERF, L. A., and LAWRENCE, J. H.: Clinical studies with aid of radio-phosphorus. III .. 142
ERF, L. A., TUTTLE, L. W., and LAWRENCE, J. H.: Clinical studies with the aid of radio-phosphorus. IV 142
K'O, Y. K., TU, C. L., and CHAN, B. C.: Effect of hard roentgen-rays on intestines of normal dogs fed on inorganic iron compounds 142
SPEERT, H.: Cyclic changes in mammary gland of Rhesus monkey 143
HOECKER, F. E.: Evolution of x-ray tube 143
HOPWOOD, F. L.: Irradiation of liquids 143
MAYNEORD, W. V.: Energy absorption 144
GRAY, L. H., and READ, J.: Neutron emission from a generator operating at 300 kv 144
HAPPEY, F.: Portable "back-scatter phantom" for x-ray measurements 144

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

McNEILL, JAMES H. Persimmon phytobezoar with case report. *Ann. Int. Med.*, May, 1941, *14*, 2142–2147.

Persimmon phytobezoar is generally seen in the United States and in Japan where the persimmon is native. It is caused by eating whole persimmons when the stomach is empty. There is a soluble astringent called shibuol just beneath the skin of the persimmon which is coagulated by the action of the stomach acids and produces the phytobezoar. These bezoars are apt to cause peptic ulcer in the prepyloric region. The bezoar itself only causes vague stomach symptoms.

The author describes a case of his own and analyzes the symptoms from this case and 11 others reported in the literature. His patient, a man of fifty-seven, came for treatment in the spring for pain in the stomach, which he had had since the preceding fall. His symptoms suggested peptic ulcer. Roentgen examination showed a filling defect in the prepyloric region and a movable translucent mass in the stomach which was diagnosed as a pedunculated epithelioma, but which proved on operation to be a phytobezoar. The ulcer was resected, though these ulcers usually heal spontaneously after the removal of the bezoar. The patient reported that he had eaten a considerable amount of persimmons one day the preceding fall just before the beginning of the symptoms and had taken no food or drink for several hours afterward.—*Audrey G. Morgan.*

SCHINDLER, RUDOLF, STEINER, PAUL E., SMITH, WILLIAM M., and DAILEY, MORRIS E. The classification of gastric carcinoma. *Surg., Gynec. & Obst.*, July, 1941, *73*, 30–39.

The histological grading of carcinomata of the stomach in use up to this time has apparently failed to show the degree of clinical malignancy. Prognosis does not seem to depend on the size of the tumor, its site or its microscopic structure.

The authors suggest a classification based on macroscopic criteria. According to this classification Type I is polypoid carcinoma, characterized by a broad base, supporting a hard hemispherical swelling. This is found in 2.9 per cent of cases. Type II is the non-infiltrating carcinomatous ulcer which constitutes 17.6 per cent of all cases, Type III is infiltrating carcinomatous ulcer, which occurs in 16.3 per cent of all cases and Type IV is of the diffuse infiltrating type which constitutes 63.2 per cent of all cases.

A table is given showing a comparison between the macroscopic and microscopic grades in 50 cases. Apparently the end-results after surgery are very good in macroscopic Types I and II and not good in Types III and IV. Further study is necessary to confirm this impression, however, and more work should be done in correlating macroscopic types, microscopic grades and surgical results in an effort to establish a surgical prognosis before operation.—*Audrey G. Morgan.*

BRUNN, HAROLD, and GOLD, RUBIN L. The surgical problem of chronic gastritis. *Surg., Gynec. & Obst.*, Jan., 1941, *72*, 31–37.

Early diagnosis of cancer of the stomach is highly desirable. Gastroscopy is a valuable aid in differential diagnosis. But there are cases in which differentiation between gastritis and cancer is extremely difficult, not only on roentgen and gastroscopic examination but even on surgical exploration. Antral gastritis, a form of chronic hyperplastic gastritis, is probably precancerous.

One of the authors, in collaboration with Pearl, described the first case of hypertrophic gastritis simulating tumor fourteen years ago. Now after fourteen years the patient still has intermittent attacks of mild abdominal distress and diarrhea, which are controlled fairly well by bland diet and dilute hydrochloric acid. Three further cases are described, in 2 of which a diagnosis of cancer was made on the basis of the clinical and roentgen findings but in which operation showed severe hypertrophic gastritis. In the third case the first roentgen examination suggested a single gastric polyp. Gastroscopy showed evidence of diffuse infiltrative changes which, however, were interpreted as being

caused by gastritis. Four months later the roentgenogram showed pronounced changes and operation revealed an advanced inoperable carcinoma of the posterior wall of the stomach.

The fact that there are such difficult cases does not argue against the value of gastroscopy as an aid in diagnosis. If neither roentgen examination or gastroscopy makes definite diagnosis possible, exploratory operation is justified, not only for the purpose of settling the diagnosis but for that of removing a possible cancer.—*Audrey G. Morgan.*

MULLEN, THOMAS F. Some factors influencing the curability of cancer of the stomach. *Surg., Gynec. & Obst.*, Feb. 14, 1941, *72*, 298–306.

From 1920 to 1938 there has been a steady increase in the number of deaths from cancer. About one-third of these are from cancer of the stomach; there are more than 100 deaths from cancer of the stomach every day of the year.

It is probable that cancer never occurs in the normal stomach, but is preceded by various types of chronic gastritis. There are substances occurring normally in the body which, under the influence of disturbed metabolism, may become carcinogenic.

One of the necessary factors in the early detection and consequent curability of cancer of the stomach is a high index of suspicion on the part of both patient and physician. Many persons have so-called dyspepsia without thinking much about it. But the public should be taught that signs of gastric distress, loss of weight and appetite, vomiting, weakness and diarrhea are symptoms that require medical attention. Another group of patients do not have digestive symptoms, but only extreme fatigue and pernicious anemia.

And physicians themselves should recognize the fact that a roentgen study of the whole gastrointestinal tract is a necessary part of a complete physical examination, particularly if there are any digestive symptoms. Also that one negative result does not rule out cancer of the stomach. The examination should be repeated at regular intervals, preferably by the same expert roentgenologist, as long as there are symptoms. Finally, if cancer of the stomach is diagnosed it should be treated only by a surgeon of the greatest skill and experience. The average operative mortality is about 25 per cent. In skilled hands the operative mortality should be less than 15 per cent. Even if surgery is only a crude method, as long as no better method is known it should be carried out with the highest degree of skill and only by surgeons with experience in this particular field.—*Audrey G. Morgan.*

BIEREN, ROLAND E. Carcinoma of the lower intestinal tract. *Surg., Gynec. & Obst.*, March, 1941, *72*, 611–615.

From January, 1922, to June, 1939, 254 cases of carcinoma of the large bowel (including 2 of the appendix and 10 of the anus) were seen at the University of Maryland Hospital. Approximately 97 per cent of the cases were followed up.

Of the 242 cases of adenocarcinoma of the colon and rectum 79, or 33 per cent, were operable. This is a low operability and is partly explained by the fact that 56 cases were considered inoperable in which there were no metastases. They were judged inoperable on account of the extent of the tumor.

Among the 79 cases operated on there were 30, or 38 per cent, of operative deaths. Peritonitis was the cause of death in 18, or 60 per cent of the cases. Twenty-four of the patients have survived three years or more. One patient has recurrence after fifteen years. This is probably another tumor. Of the 25 remaining cases 14 have died and 11 are still living, having survived varying periods less than three years. Two of these have liver metastases.

Of the 163 inoperable cases, aside from 3 survivals of fourteen years, thirteen years and six years under electrocoagulation and radium, and 1 survival of four and one-half years under radium alone, there were no survivals of over three years and the average survival was fifteen months.

Thirty-six patients were treated with radium. All of the three long-term survivals mentioned above were Grade III tumors. Dukes' classification was used, according to which A indicates that the tumor is limited to the mucosa and submucosa, B indicates involvement of the muscularis and C peritoneal or regional node involvement. The survival of one inoperable patient for fourteen years casts some doubt on the criteria of inoperability adopted.

Operation should be performed whenever possible as the chance of survival in untreated cases is poor, while if adequate excision is performed and the patient survives the operation his chances for survival are good.—*Audrey G. Morgan.*

BUIRGE, RAYMOND E. Carcinoma of the large intestine. *Arch. Surg.*, May, 1941, *42*, 801–818.

This article is based on 416 cases of malignant tumor of the large intestine found among 26,798 autopsy records at the University of Minnesota from 1910 to 1937. The percentage of male to female patients was 1.77 to 1; their average age was fifty years, six months. The most frequent sites of the cancer were the rectum, the sigmoid flexure and the cecum.

There are no specific symptoms early in the disease. Generally the patient does not come for treatment until hemorrhage or signs of obstruction develop. A part of the blame for failure to come earlier for treatment rests on the patient himself and part of it on the general practitioner to whom he first goes for advice. Not only should the public be educated in regard to the early signs of cancer, but the family physician should be trained in early diagnosis and treatment. If symptoms such as melena, changes in intestinal habit, diarrhea or constipation or alternation of the two, weakness, anemia, loss of weight or signs of intestinal obstruction appear, complete clinical and roentgen examination should be made at once. Roentgen examination is absolutely indispensable for the early diagnosis of cancer of the colon. Among 97 diagnoses based on roentgen studies of the colon, 85 per cent were correct. Digital examination of the rectum and the use of the sigmoidoscope are useful aids in the diagnosis of cancer of the distal part of the colon.

The most frequent mistaken diagnoses made in cancer of the colon are discussed and the suggestion made that the trainees in cancer clinics should carefully correlate the histological and clinical findings in all cases. Such a study carried out in all cancer institutes over a period of five years would give invaluable information.—*Audrey G. Morgan.*

MACDONALD, DEAN. Common bile duct peristalsis; preliminary report. *Surg., Gynec. & Obst.*, Dec., 1941, *73*, 864–866.

A case is described in which roentgenoscopic examination of a pathological common bile duct showed clear evidence of peristalsis of the duct. Cholangiograms are given showing the evidence on which this conclusion was based. There were changes in the internal diameter of the duct which could have been caused only by irritation by the tube, contraction of the sphincter muscle or peristalsis. Irritation could not produce such changes if there was not an inherent ability to contract and relax. The constriction was 1 inch from the end of the duct and sphincter tissue rarely extends so far up.

Peristalsis should be expected in the common duct because it is an integral part of the bile tract and an uninterrupted flow of bile is necessary to good health.

The clinical conclusion to be drawn from this finding is that serial cholangiograms should be taken, as the findings on a single plate may be misleading.—*Audrey G. Morgan.*

FELDMAN, MAURICE. The terminal common bile duct and duodenal papilla; roentgenological consideration. *Surg., Gynec. & Obst.*, Dec., 1941, *73*, 838–844.

Little attention has been paid in the roentgenological literature to the changes in the terminal common bile duct and the papilla of the duodenum. Of course a knowledge of the normal roentgen appearance of this part of the digestive tract is a necessary prerequisite to an interpretation of pathological changes.

The author has previously published a description of the normal roentgen appearance of the ampullary portion of the duodenum and in this article he describes and illustrates with roentgenograms pathological changes in this area which may be of diagnostic significance, including enlargement and broadening of the plica longitudinalis duodeni fold, encroachment of the enlarged duodenal fold on the lumen of the duodenum, mucosal changes surrounding the longitudinal fold and changes in the pattern of the mucosa of the ampulla, enlargement of the major duodenal papilla, filling defect in the outline of the duodenum, varying degrees of stenosis, defect from secondary ulceration, invasion of the pancreas by carcinoma, which may cause signs of pressure on the duodenum, cholecystographic changes which cause nonfilling of the gallbladder when the bile duct is occluded and pressure defect of the stomach in late cases.—*Audrey G. Morgan.*

ARCE, JOSÉ. Hydatid cyst of the liver. *Arch. Surg.*, June, 1941, *42*, 973–987.

The surgical treatment of hydatid cyst of the liver is discussed and illustrations given showing the technique of the different operations used: midline laparotomy, high laparotomy, transdiaphragmatic parapleural laparotomy.

and transpleural transdiaphragmatic thoracolaparotomy. The author uses his own incision, called in Argentina Arce's gridiron transverse laparotomy, for all surgical conditions of the biliary system and the right lobe of the liver, including hydatid cysts. This is simply McBurney's gridiron incision for appendectomy used in the upper part of the abdomen.

When the cyst has been reached it can be treated by removal of the parasite, followed by suture of the adventitia without drainage, removal of the parasite followed by marsupialization and drainage of the adventitia, removal of the parasite without suturing or draining the adventitia, or total removal of the cyst.

Roentgenograms are given of cysts in different parts of the liver and the indications for the various types of operation discussed. Sometimes the roentgenogram shows calcification of the adventitia. If such a cyst is not too large or too far from the periphery of the organ it should be totally removed. Marsupialization should be used for cysts opening into the biliary tract or into a bronchus.—*Audrey G. Morgan.*

SKELETAL SYSTEM

LACHMAN, ERNEST. The limitations of the roentgen diagnosis of fractures. *Surg., Gynec. & Obst.*, Aug., 1941, *73*, 140–151.

Since roentgen rays have been used in medicine the opinion seems to have become established that the roentgen report of a fracture is something absolutely objective and definite and not subject to errors of interpretation.

The author points out that this is by no means true and that there are very definite limitations to the accuracy of roentgen diagnosis of fractures. In order for a physician to interpret roentgen findings correctly he must know the laws of roentgen physics, particularly those of projective geometry. He must know the normal roentgen anatomy of the skeleton at different ages and the roentgen symptomatology of bone diseases and must take into consideration the possibility of supernumerary bones and other abnormalities that may simulate fracture.

Sometimes the patient is so severely injured that it is impossible to make roentgenograms in all the projections necessary for roentgen diagnosis. It may not be possible to visualize a fracture line in cartilage or because it is too minute to be shown. The projections used may not be chosen properly to show the fracture in question. Complex parts of the skeleton, such as the skull and vertebrae, are apt not to be shown because of superimposition of other bones or parts of bones. And in cases of multiple fracture some of the fractures may not be included in the roentgenogram.

Special care is necessary in evaluating the displacement of fragments. Angulation of fragments toward or away from the plane of the roentgen film may cause misinterpretation. The introduction of the lateral projection has decidedly influenced the diagnosis and treatment of fractures of the neck of the femur, and doubtless further technical improvements will overcome others of the limitations in the roentgen diagnosis of fracture. But the physician and roentgenologist must recognize the existence of such limitations.

None of the signs of healing of fracture are absolute. A fracture line may be masked for instance by exuberant callus. The clinical findings must be considered in evaluating bone repair. The roentgen signs of fracture may disappear so completely that it is impossible to say that there has ever been a fracture. This may be of importance in medicolegal cases, as may the fact that after about a year it is impossible to judge the date of a fracture from the roentgenogram.—*Audrey G. Morgan.*

RIESENMAN, F. REGIS, and YATER, WALLACE M. Osteogenesis imperfecta; its incidence and manifestations in seven families. *Arch. Int. Med.*, May, 1941, *67*, 950–967.

Seven white families living near Washington, D. C. were studied, and 91 cases of osteogenesis imperfecta were discovered among their 255 members. Four of the families are described in detail and family trees given showing the incidence of the disease.

The triad of symptoms in this disease is blue sclerotics, occurring in 100 per cent of the cases, brittle bones with multiple fractures in 65 per cent and otosclerosis with progressive deafness in 43 per cent. The roentgenogram shows the bones of the extremities very slender with greatly expanded ends. There are peculiar cross striations. The bone is very dense and hard and looks and cuts like marble.

The disease is evidently due to a hereditary inferiority of the mesenchyme and it is possible that improvement in its treatment may be brought about by a more complete knowledge of genetics and eugenics. There is no proof that

the endocrine system is involved or mineral metabolism affected.

The disease may develop during intrauterine life and the child may have multiple fractures at birth. This form is rare. All the cases in this series belonged to the post-natal or infantile type. These children have blue scleras at birth.

There is no specific treatment. Early orthopedic treatment may be useful in preventing crippling. The use of thymus extract has been recommended because of the influence of the thymus on the growth and development of bone. But it has generally not been given until the child has had several fractures. It would be more logical to give it to the mother during pregnancy in affected families, and to begin its administration at once to any child born with blue scleras.—*Audrey G. Morgan.*

COUCH, J. H., and ROBERTSON, H. F. Occurrence of postoperative acidosis and pagetoid bone changes in hyperparathyroidism. *Surg., Gynec. & Obst.*, August, 1941, *73*, 165–174.

Two cases of parathyroid tumor associated with hyperparathyroidism are described which illustrate two different aspects of the condition. The first case was in a woman of fifty-two who first presented the signs of hypercalcemia and then of multiple bone cysts due to decalcification. A diagnosis of hyperparathyroidism was made and the tumor removed by operation. Ten hours after operation a severe acidosis developed. The danger of such postoperative acidosis in this condition should be borne in mind. It is probably caused by the retention in the blood of acid radicals, such as sulphates, phosphates and chlorides, while sodium is excreted freely by the kidneys and calcium is retained in the bones. The basic radicals are depleted and acidosis occurs. This same mechanism may cause hypocalcemic tetany. Either of these conditions may be fatal. The acidosis was successfully treated in this case by giving sodium bicarbonate intravenously. A salt-free diet for a week or so before parathyroidectomy would be a typical preventive measure in these cases.

In the second case in a woman of sixty-four the roentgenogram showed bone changes resembling those of Paget's disease. The changes were probably caused by alternate exacerbations and remissions of parathyroid activity which brought about alternate periods of decalcification and recalcification of bone.—*Audrey G. Morgan.*

BATTS, MARTIN. Periosteal fibrosarcoma. *Arch. Surg.*, March, 1941, *42*, 566–576.

Periosteal fibrosarcoma is an unusual type of tumor. In a series of 200 primary malignant bone tumors seen at the University Hospital, Ann Arbor, Mich., 27 were of this type. About two-thirds of the patients were males and 21 of them, or 78 per cent, were less than forty years of age. According to the histories neither heredity nor trauma played any important part in causing the tumor.

The average duration of symptoms was twenty months, which is relatively long as compared with other malignant bone tumors. The commonest symptoms were pain and swelling. In 3 cases there was tumor formation without any history of pain. The tumors were deep-seated, smooth and not fixed to the overlying tissues, but they were relatively immobile because of firm fixation to the periosteum.

Roentgen examination showed two types of changes, destructive and reactive. Roentgenograms showing these types of change are given. Destructive changes were more frequent than reactive ones. The histopathological findings were essentially the same as those seen in any sarcoma originating from fibrous tissue.

The tumors were divided into four grades according to the degree of malignancy. Tables are given showing the percentage of five year survivals, as based on site of tumor, type of treatment and degree of malignancy. They indicate that the most important factor in prognosis is the degree of malignancy. All of the cases of Stage I showed five year survival, 70 per cent of those of Stage II and none of those of Stages III and IV. The site of the tumor apparently does not affect prognosis and the type of treatment was a less decisive factor than the degree of malignancy. Local excision plus roentgen therapy gave the highest percentage of five year survival.

Follow-up studies were made in 25, or 93 per cent, of the cases. Ten patients, or 40 per cent, had survived for more than five years after treatment. Three of the patients died of malignancy more than five years after treatment, showing that five year survival does not mean cure. Most of the deaths, 13 or 52 per cent, were from metastases in the lungs.—*Audrey G. Morgan.*

BADGLEY, CARL E., and BATTS, MARTIN, JR. Osteogenic sarcoma. *Arch. Surg.*, Oct., 1941, *43*, 541–550.

Osteogenic sarcoma is the most common type of primary malignant bone tumor, constituting almost half of the total number of bone tumors reported by the American Registry of Bone Tumors. At the University Hospital, Ann Arbor, Mich., a series of 80 cases treated from 1925 to 1938 has been studied. In half of these cases the patients were in the second decade of life. The average age on admission was twenty-nine years, the youngest patient was eight years of age, the oldest seventy-two. Sixty-four per cent of the patients were men and 36 per cent women. There was a family history of tumor in only 13 per cent of the cases and a history of trauma in about a third of them.

The average duration of symptoms from onset to time of admission was thirteen months. The chief symptoms were pain and swelling, the pain preceding the swelling in the majority of cases. In almost all the cases the patients were in good health when the symptoms began. There was a palpable tumor in 73 cases, or 91 per cent, which was hard and moderately tender. The regional lymph nodes were enlarged in only 2 of the cases. A few of the patients had a low-grade fever.

The lesions occurred most frequently in the ends of the long bones and in half of this series of cases they were at or near the knee joint.

The treatment of choice in this series was radical amputation, generally not preceded by irradiation. When roentgen treatment was given after operation it was generally as a palliative measure, usually for lung metastases. If amputation was impossible local excision was performed, generally followed by roentgen treatment.

Follow-up studies showed that 63 per cent of the patients had died. Of the other 17 one had metastases and the others were well. There were 15 five year survivals, or 19 per cent, and 4 ten year survivals, or 5 per cent. One patient was alive and well fourteen years and seven months after a mid-thigh amputation. The average survival in the cases of death was thirty-one months. That even a ten year survival does not necessarily mean cure is shown by the fact that one patient died of pulmonary metastases that developed thirteen years after a mid-thigh amputation.

Prognosis is better in older patients than in younger ones, in cases in which symptoms appeared relatively late, in distal than in central lesions of the extremities and in the more highly differentiated types of tumor. The longer the survival after operation, the more favorable the prognosis.

It has not been proved that biopsy endangers the patient's life, though in this series the average period of survival in cases in which biopsy had been done was twenty-eight months, and in those in which it was not done thirty-five months.—*Audrey G. Morgan.*

GENERAL

CAMPBELL, DARRELL A. Carcinoma of the upper extremity. *Arch. Surg.*, Nov., 1941, *43*, 803–810.

Carcinoma of the upper extremity is not common. It constitutes less than 10 per cent of all carcinoma.

A series of 36 cases treated at the University Hospital, Ann Arbor, Mich., is discussed. The most frequent etiological factor was carcinomatous change occurring in keratoses. These carcinomata frequently develop in the scars of old burns and in the early days of the use of roentgen rays they often developed after roentgen and radium irradiation. Lupus vulgaris is a common etiological factor.

In this series of cases 32 of the patients were men and 4 women. Wide surgical removal of the lesion and irradiation of the site and of the regional glands proved the best treatment. Only 4 of the patients, or 11 per cent, survived five years or more without recurrence. But a considerable number died of intercurrent disease before the end of the five year period was reached, and if these and the patients who have not yet reached the end of the five year period are counted the percentage of cures becomes seventy-two. In half the cases there were unrelated tumors of other parts of the body.

Although 15 of the patients have died, only 7 died directly of the carcinoma. The others died of intercurrent disease. The average of those who died from carcinoma was 52.7 years and of those who died from intercurrent disease seventy-five years.—*Audrey G. Morgan.*

CAMIEL, MORTIMER R., and BOLKER, HERMAN. Carcinoma erysipelatodes; subepidermal lymphatic metastases confused with opera-

tive sequelae. *Surg., Gynec. & Obst.*, March, 1941, *72*, 635–641.

Unna noticed the resemblance of certain tumor metastases to erysipelas. This condition was first named erysipelas carcinomatosa in 1924 by Kuettner, but Rasch in 1931 criticized this name and suggested that of carcinoma erysipelatodes because the condition is primarily cancerous.

The authors describe 2 cases which occurred after operation and roentgen treatment for carcinoma of the breast in women forty-seven and forty-eight years of age. The reddened area which developed around the operation scar was in both cases interpreted as postoperative inflammation or radiodermatitis. Such a severe dermatitis caused by irradiation would, of course, be of medicolegal importance. A study of histological sections in both cases, however, showed that the lesions were cancerous.

More than 200 serial sections were studied in an effort to determine whether the metastasis had been disseminated through the blood or lymphatic channels. Apparently it had been through the subepidermal lymphatics and tissue spaces rather than through the veins, as no erythrocytes were found in the vessels that contained the tumor cells. This is a chronic and not an acute process and the well demarcated, reddened and advancing border is the only feature that it has in common with erysipelas.—*Audrey G. Morgan.*

SAPHIR, OTTO, and PARKER, MORRIS L. Metastasis of primary carcinoma of the breast; with special reference to spleen, adrenal glands and ovaries. *Arch. Surg.*, June, 1941, *42*, 1003–1018.

There is very little definite information in the literature in regard to metastases from cancer of the breast. The authors therefore thought it worth while to report the pathological findings in 43 cases from the Michael Reese Hospital. The commonest site of metastases was in the lungs which were involved in 28 cases, and next the liver in 24 cases. This was followed by involvement of the adrenal glands in 19 cases, the spleen in 10 cases and the ovaries in 7 cases. It has been said that carcinoma of the spleen secondary to cancer of the breast is part of a generalized microscopic carcinomatosis. In 3 of the cases there were no metastases.

A table is given showing the period of survival after operation. It is evident that neither the length of life nor the spread and number of metastases is dependent on the type of carcinoma. But a high degree of malignancy is indicated by the breaking down of the lining of the gland structures and the dissemination of isolated tumor cells in the surrounding breast tissue. Most of the tumors which caused metastases in the spleen, ovaries and adrenal glands showed an infiltration of isolated carcinoma cells outside the primary tumor. This was particularly true of the signet ring cell variety of mucinous carcinoma.

With reference to treatment, in this series of cases the results were no better when irradiation was given following operation than when it was not. This would seem to indicate that irradiation is not effective for metastases. But the number was small and the tumors particularly malignant, so that no definite conclusions can be drawn in regard to this point.—*Audrey G. Morgan.*

BRAUND, RALPH R., and MARTIN, HAYES E. Distant metastasis in cancer of the upper respiratory and alimentary tracts. *Surg., Gynec. & Obst.*, July, 1941, *73*, 63–71.

It is well known that the regional lymph nodes are very frequently involved in cancer of the upper respiratory and intestinal tracts but very little has been written about systemic metastases from these tumors.

The records of the Memorial Hospital in New York show autopsies on 308 patients who died of cancer in these locations. Histological examination of the primary tumor was made in 284 of the cases which are considered in this article. They are divided into tumors of the lip, mucosa of the cheek, floor of the mouth, gums, tongue, palate, tonsil, nasal cavity and sinuses, wall of the pharynx, extrinsic and intrinsic larynx and esophagus. Tables are given showing the incidence of distant metastases from these different sites, the distribution of the distant metastases and the relationship of the duration of the disease to the occurrence of distant metastases.

The lowest incidence of distant metastases was from tumors of the floor of the mouth, 6.2 per cent, and the highest from those of the nasal cavity and sinuses, 35.7 per cent. Of the whole 284 cases, 23.2 per cent showed distant metastases. These were blood-borne metastases. The most frequent metastases were in the lungs, liver and pleura, which showed 33, 24 and 18 cases of metastasis respectively.

It is generally believed that cancer of the aged is comparatively benign while in the young it is particularly malignant. This belief was not confirmed by these cases, though the 66 patients with visceral metastases showed an average age of 55.8 years while the average age of the patients without visceral metastasis was 59.4 years. Syphilis seemed to have no causal significance in the production of distant metastases. Only 3 of these patients had syphilis.

Only the groups with cancer of the mucosa of the cheek and of the esophagus showed a higher incidence of visceral metastasis with a longer history of disease before treatment. In the other groups there was a shorter history from onset to treatment in the cases with distant metastases.

The morphology of the tumor was of little value in determining the probability of distant metastasis. Among the patients with epidermoid carcinoma none had visceral metastases who had not at some time during the course of the disease shown involvement of the cervical lymph nodes, but 2 patients with adenocarcinoma of the palate had visceral metastases not preceded by lymph node involvement.—*Audrey G. Morgan.*

List, Carl F. Intraspinal epidermoids, dermoids, and dermal sinuses. *Surg., Gynec. & Obst.*, Oct., 1941, *73*, 525–538.

Epidermoids, dermoids and dermal sinuses are structures that contain elements of the skin. They are dysembryonic malformations rather than true tumors, but are called tumors here because of their tendency to expand. Epidermoids are made up of the superficial layers of the skin, dermoids contain all layers of the skin and also its accessory organs, such as sweat and sebaceous glands and hair follicles. Dermoid sinuses are tubular structures in direct connection with the skin. The embryological theories in regard to their origin are discussed.

The author describes and illustrates with roentgenograms 5 cases of his own which brought the total number of cases at the time of the writing of his article up to 56. Since then he has had another case and 4 more have appeared in the literature, making a total of 61. These tumors are in the majority of cases below the 12th dorsal vertebra and many of them are in the cauda equina. Only 1 case has been described in the cervical cord. Almost two-thirds of all the lesions were within the leptomeninges, one-fifth were frankly intramedullary and only a few extradural. Most of the lesions were on the posterior surface of the cord.

No matter at what age they become manifest these tumors are present, though latent, at birth. Epidermoids and dermoids show a tendency to long remissions. The neurological symptoms and spinal fluid findings are about the same as in other slowly growing tumors of the spinal cord. The total protein in the spinal fluid does not reach the very high levels that it does in neurinomas.

As these are benign encapsulated tumors their surgical removal should be simple, but results have not been good until the past fifteen years. Total removal may be impossible because of firm adherence of the capsule to the cord and nerve roots. And in intramedullary cases it may be impossible to remove the whole tumor without injuring the cord. But even intracapsular enucleation with partial removal may bring about improvement for a long time. Dermal sinuses should be totally excised. If the sinus is infected the results are improved by the use of sulfanilamide, sulfathiazole and similar drugs.—*Audrey G. Morgan.*

Donhauser, J. Lewi, and de Rouville, William H. Multiple myeloma, with special reference to soft tissue metastasis. *Arch. Surg.*, Dec., 1941, *43*, 946–1020.

Multiple myeloma is a primary malignant tumor of bone marrow with multiple foci in the bones. It is usually associated with anemia and Bence-Jones proteinuria. Treatment is hopeless and death generally occurs within two years. This form of tumor generally develops in the sixth decade of life with the peak at fifty-five. As it most frequently involves the bones that contain the most red marrow it is commonest in the vertebrae, ribs, sternum, clavicle and skull, though any of the bones may become involved. The tumor is very vascular and more or less gelatinous. It is definitely destructive of bone and there is no evidence of bone repair. Spontaneous fractures are very frequent. Soft tissue may become involved also, particularly the blood-forming tissues. The only change in the blood may be anemia, but in most cases there is an increase of lymphocytes and the myelocytes often increase to 10 per cent.

In any patient who complains of backache or obscure pain in the bones, especially if he is in the sixth decade of life, myeloma should be suspected. The disease is so rare that often physi-

cians do not suspect it and many mistaken diagnoses are made. When it is suspected the pathologist, chemist and roentgenologist should be called in for confirmation of the diagnosis. The chemist should make complete examinations of the urine with regard to specific gravity, presence or absence of albumin and sugar, the calcium content and the presence of Bence-Jones protein. Determinations of blood calcium, phosphorus, phosphatase, total protein, including albumin-globulin ratio, non-protein nitrogen, creatinine, urea and uric acid should be made.

Roentgen examination must be made by a roentgenologist who can detect very slight differences in the density of bone. The most characteristic finding is decreased density of the affected bones with absorption and replacement of lime salts by tumor tissue. There are usually sharply punched-out holes in the bones. These are seen in a number of other conditions, however, which must be ruled out by exclusion. There is no compensating hyperostosis.

Five cases are described in detail and illustrated with roentgenograms and photomicrographs. Though it has been claimed that metastases are rare or non-existent in this disease there were metastases in 3 of these 5 cases. There was widespread direct extension of the disease in one case. In 3 of the cases there was Bence-Jones protein in the urine. The urinary findings were inconstant. In 4 of the cases severe pain in the back was the first symptom. There was low blood pressure in 2 of the cases but this is not a pathognomonic symptom.—*Audrey G. Morgan.*

LUTZ, J. FLETCHER. Calcinosis universalis. *Ann. Int. Med.*, Jan., 1941, *14*, 1270–1282.

Calcinosis universalis is a definite disease entity characterized by the deposition of calcium in the subcutaneous tissue, muscles and sometimes along the nerve trunks. There are none of the abnormalities which usually cause pathological calcification, such as chronic inflammation, infarction, hemorrhage or tissue necrosis. Blood calcium is normal in the majority of cases, most of which are associated with scleroderma. Diagnosis is readily made by roentgen examination which shows the calcium deposits throughout the subcutaneous tissue. There is no evidence of bone involvement such as is seen in parathyroid disease. The patient's general health may be affected by the mechanical disturbance resulting from the stiffening of the muscles.

Prognosis is unfavorable as to cure. There is no known effective treatment. The disease is slowly progressive but does not generally cause death. In the one case in which autopsy has been reported the patient died of an intercurrent disease. No changes were found in the parathyroids, though the patient had had the disease for thirty-seven years.

A case is described in a schoolgirl sixteen years of age in whom a fistula of the left hip developed after a fall on the hip. Biopsy and chemical examination showed a rich deposit of calcium salts, mostly phosphate, in the muscle fascia and superficial layers of muscle tissue of the leg but no true ossification, and no neoplastic bone formation. Roentgenograms and a photomicrograph of the histological findings are given.—*Audrey G. Morgan.*

ROENTGEN AND RADIUM THERAPY

WALLACE, WILLIAM S. Studies in radiation sickness. II. Vitamins B_1 and C and the small intestinal change in radiation sickness. *South. M. J.*, Feb., 1941, *34*, 170–173.

The author describes the technique of irradiation for carcinoma of the cervix used at Duke Hospital, and the treatment of these patients with vitamins B_1 and C in an effort to prevent radiation sickness.

The patients treated with vitamin B_1 were given daily intramuscular injections of 10 mg. synthetic thiamin chloride, corresponding to 3,000 international units. Those treated with vitamin C were given daily doses of 50 mg., or 1,000 international units, of sodium ascorbic acid in the form of "cevalin." These were large doses and it is improbable that larger ones would have had any further effect.

These vitamins almost completely eliminated the severe nausea and vomiting of radiation sickness and the patients were more comfortable subjectively, but they had no effect on the diarrhea and did not prevent the changes in the ileum seen after heavy irradiation. These changes resemble those of deficiency states, but they are evidently not caused by lack of vitamins B_1 and C.

In the discussion Dr. Keith said that he believed the dosage of 300 r per day over two fields reported in this paper was quite high, even though 200 kv. was used. Whenever 300 r a day

is given over the abdomen it causes some nausea. With high voltage and high filtration he usually does not give more than 200 r per day. He has had more relief from radiation sickness from nicotinic acid than anything else, 50 mg. in a glass of water thirty minutes before meals.

The importance of the psychic factor in radiation sickness was mentioned.—*Audrey G. Morgan.*

DALAND, ERNEST M. Radiation damage to tissue and its repair. *Surg., Gynec. & Obst.*, Feb. 15, 1941, *72*, 372–383.

In the early period of the use of roentgen rays much damage was done because of lack of accurate knowledge of the action of the rays and of means for protection. Now with more adequate protection damage is less but still occurs.

It may be early, in the form of erythema and ulceration or late in the form of degenerative changes in the tissues and possibly the development of cancer in irradiated areas. Infection in a heavily irradiated area may cause necrosis and sloughing. The mucous membrane of neighboring organs may be almost as sensitive to irradiation as the tumor itself and serious damage may be due to this cause. Considerable damage has been done by a method of removal of superfluous hair by beauty parlors in use some years ago. It was really a roentgen treatment and without knowledge of dosage on the part of the operators, the results were serious in many cases.

Irradiation of a region does greater harm if the circulation is poor. Often the circulation in the extremities is not good and as a result they do not bear irradiation as well as more vascular parts of the body. Circulation is poorer after irradiation and if an artery supplying an area damaged in this way is ligated later on surgical operation necrosis of the whole area may occur.

Cancer may develop in an irradiated area after varying intervals. The shortest interval seen by the author between irradiation and the development of cancer was two and one-half years, the longest eighteen years. Roentgen cancer is usually of the epidermoid type. Metastasis begins late but when it does begin it extends rapidly, first through the lymphatics and then through the blood. Twenty-five cases of various types of injury from roentgen irradiation are described and illustrated with photographs.—*Audrey G. Morgan.*

YOUNG, FORREST. The treatment of persistent recurrent basal cell carcinoma of the face. *Surg., Gynec. & Obst.*, August, 1941, *73*, 152–164.

Basal cell carcinoma usually occurs on exposed areas, such as the face. It is comparatively easy of cure either by irradiation, cautery or electrocoagulation. Sometimes, however, the initial treatment is inadequate and there is persistent recurrence, which may make this a very serious condition.

If the growth recurs radical removal must be performed even if disfigurement results. The physician or surgeon is often hesitant in treating these cases because of the fear of causing disfigurement. But often the tumor extends under apparently normal skin and care must be taken to excise well beyond the limits of the lesion. Surgery is preferable to irradiation at this stage. The author believes repair should be done immediately rather than after an interval of twelve to eighteen months as has often been advocated. If grafting is necessary the flap can be prepared before the operation and applied immediately after it. If it is a pedicled flap the pedicle can be cut some four to six weeks later. This method requires a minimum of hospitalization.

Six cases treated in his way are described in detail and illustrated with roentgenograms.—*Audrey G. Morgan.*

ARBUCKLE, MILLARD F., and STUTSMAN, A. C. Pharyngeal and laryngopharyngeal cancer; a new combination of surgery and radiation therapy in their treatment. *South. M. J.*, Feb., 1941, *34*, 219–221.

Four cases are reported in which the authors removed the normal thyroid and epiglottic cartilages before radiotherapy was given. This was done because in these cases, even when the tumor is destroyed by irradiation, the cartilage becomes edematous and finally breaks down.

In the discussion Dr. Le Jeune said that he had had poor results from irradiation in laryngeal cancer. He had had no experience with removal of the laryngeal cartilage, but if irradiation does not help the metastatic glands he could not see how it would help lesions inside the larynx if the cartilage was removed. If irradiation is effective it would be of special value in tumors of the pyriform fossa or the hypopharyngeal area which are not accessible to operation.

Dr. Arbuckle replied that he did not know whether their method would be found an improvement but that any method which promised improvement was worth trying, as the mortality in these cases, except in genuine cordal cancer, is still distressingly high. He believes surgery is indicated in operable cases, but irradiation alone or in combination with surgery, should be used in cases in which the location makes it difficult or impossible to remove all of the tumor by surgery.—*Audrey G. Morgan.*

RHINEHART, D. A., and RHINEHART, B. A. Protracted roentgen treatment of malignancies particularly of the head and face. *South. M. J.*, August, 1941, *34*, 820–823.

The fundamental principles of Coutard's protracted fractional method of roentgen therapy are high voltage, heavy filtration, low intensity, long single exposures, long treatment time and high total dosage. There are many modifications of the treatment. The technical factors most frequently used are: 200 to 220 kv., 5 to 25 ma., a distance of 50 to 70 cm., filtration from 0.75 to 2 mm. copper and 1 to 2 mm. aluminum and a daily dose of 200 to 250 roentgens, measured in air. Often a composite filter of 0.4 mm. tin plus 0.25 mm. copper plus 1.0 mm. aluminum is used instead of the pure copper. It gives a beam equivalent in quality to that of more than 2 mm. copper but at a greater intensity, so that treatment time is shortened.

Because of the high total dosage given, up to 6,000 to 8,000 r, the reactions are apt to be severe. It is a treatment that is hard for both patient and physician.

It is used chiefly for tumors of the mouth, pharynx, larynx, tongue and tonsils. A table is given showing the results in 61 cases. Thirty-two of the patients are dead, 29 of them of the original disease. Twenty-five are living, 20 of them apparently free of cancer. Treatment has been satisfactory in 23 cases, or 37.7 per cent.—*Audrey G. Morgan.*

NEW, GORDON B., and HALLBERG, O. ERIK. The end-results of the treatment of malignant tumors of the palate. *Surg., Gynec. & Obst.*, 1941, *73*, 520–524.

The authors review 173 cases of malignant tumors of the palate treated at the Mayo Clinic from 1907 to 1939. During this time 236 cases of benign tumor of the palate were seen.

The most frequent tumors at this site are adenocarcinoma of the mixed type (76 cases in this series) and squamous cell epithelioma (84 cases in this series).

Among the cases of adenocarcinoma of the mixed type the average age of the patients was fifty years for males and forty-two years for females. The average duration of symptoms was 4.75 years, the shortest one month and the longest thirty years. In almost half the cases the tumor was at the junction of the hard and soft palates, which is the chief location of the openings of the ducts of the mucous glands. These tumors can generally be diagnosed easily from the location, the long duration and the movable, hard, nodular tumor. Fibromas or fibrosarcomas are the only tumors that may be confused with them.

These tumors are removed surgically whenever possible. If it is doubtful whether the whole tumor has been removed, radium seeds or needles are used at the time of operation. In all but one of the cases here reported the tumor was removed through the mouth. The lymph nodes of the neck were not removed unless they showed metastases. Generally these tumors do not metastasize. In 7 cases irradiation had been used before the patients came to the Clinic and the tumors were inoperable. In these cases only irradiation was used. The number of five year survivals was 46, or 88 per cent of the patients traced. There were 29 ten year survivals, or 78 per cent of the 37 patients traced. This shows that these tumors were not very malignant.

Among the 84 patients with squamous cell epithelioma the average age was 58.2 years; 10.7 per cent of the patients were women. The preferred treatment was removal by surgical diathermy under intratracheal nitrous oxide-oxygen anesthesia or intravenous pentothal sodium. The number of five year survivals was 20, or 38 per cent of the 52 patients traced. Five year survival in cases of Grade I was 100 per cent, Grade II, 44 per cent, Grade III, 38 per cent, and Grade IV none.

The other 13 cases were made up of 3 of melanoepithelioma, 4 of fibrosarcoma, 1 each of fibromyxosarcoma, myxosarcoma and chondrosarcoma and 3 of lymphosarcoma.

Among the cases of melanoepithelioma there were two survivals of four and two years. The other patient was given only palliative irradiation. The 4 patients with fibrosarcoma showed freedom from recurrence after five, ten and

twenty years. Only palliative irradiation was used in the fourth case. The patient with fibromyxosarcoma was treated with radium but died two years later. The patient with myxosarcoma died a month after treatment. The one with chondrosarcoma had had a tumor of the palate removed ten years before admission to the Clinic. She was in very bad condition on admission and only palliative roentgen irradiation was used. All of the 3 patients with lymphosarcoma had palpable lymph nodes when examined. They were all given palliative roentgen treatment but all of them died within eleven months of generalized metastases.—*Audrey G. Morgan.*

KAMPERMAN, GEORGE. The present status of treatment of gynecological cancer; with special reference to results obtained since introduction of supervoltage roentgen therapy. *Surg., Gynec. & Obst.*, Feb. 15, 1941, *72*, 384–390.

This article reviews the 845 cases of gynecological cancer treated at Harper Hospital, Detroit, Mich., from 1922 to 1935 on the basis of the five and ten year survival figures. They include 636 cases of cancer of the cervix, 77 of cancer of the fundus, 171 of cancer of the ovary and 31 of cancer of the external genitalia.

Tables are given showing the results in these groups. Only survivals were counted. All patients who died were assumed to have died of cancer and those lost sight of were also counted as dead of cancer, though some of them doubtless survived. Therefore the survival figures given are the lowest possible.

At first treatment was with 200 kv. constant potential, 1 mm. copper filter, but in 1933 supervoltage roentgen treatment was instituted with 500 to 600 kv. constant potential, 7 mm. copper filter. Only cases that were inoperable and in which intrauterine radium treatment could not be given were treated with roentgen irradiation alone. Improvement in the survival curves since the introduction of supervoltage therapy indicates that it does give better results than earlier methods.

In carcinoma of the cervix in the earlier years operation was performed in operable cases, followed by irradiation. Since 1928 the intrauterine use of radium has been relied on chiefly, the largest tolerance dose being given—a total dosage of 7,200 to 10,000 milligram-hours. Roentgen rays are used to irradiate areas around the periphery of the pelvis outside the action of the radium. From 1922 to 1928 the five and ten year survivals averaged 16 and 12 per cent, from 1928 to 1933, 21 and 15 per cent, and from the introduction of supervoltage therapy to 1935 the five year survivals reached 35 per cent.

In carcinoma of the uterine fundus preliminary treatment with intrauterine radium and roentgen rays is given, followed in six to ten weeks by operation. This increased five year survivals to 71 per cent as compared with 55 per cent in the period when operation was performed first. The absolute five year survivals since the introduction of supervoltage average 50 per cent.

The curves for five and ten year survival in carcinoma of the ovary are 20 and 18 per cent for the whole time. Supervoltage roentgen therapy did not bring about any improvement in this group.

Treatment must be strictly individualized in carcinoma of the external genitalia. The five year survivals for the whole period average about 16 per cent and the ten year survivals almost the same.—*Audrey G. Morgan.*

MISCELLANEOUS

HAMES, FRED. Accurate placement of radon seed by suture method. *South. M. J.*, May, 1941, *34*, 462–464.

In the ordinary methods of using radon seeds they tend to bunch together in a dependent part because of the heaviness of the gold. This may causes radiation necrosis of bone.

The author describes a method by which one to twenty radon seeds with gold walls 0.3 mm. thick can be applied in one piece of material. The method cannot be used for radium. The material is a woven silk structure with openings 1 cm. apart for the seeds. As it is woven the opening closes after the seed is inserted. Each piece of material is fitted with a small metal collar into which the needle is screwed so that the suture can be placed without having to pass it through the tissue doubled. After it is placed it is fastened at each end by crushing a hollow lead shot over a threaded glass bead. After the radiation has been given the suture holding the seed can be removed as simply as removing a capillary drain. The seed can be recovered by burning away the silk material.

The method is simple and easy to apply, it prevents radiation necrosis of bone, reduces secondary rays and makes the patient more comfortable, as he can empty his mouth and take food and drink.—*Audrey G. Morgan.*

ERF, L. A. and LAWRENCE, J. H. Clinical studies with the aid of radio-phosphorus. III. The absorption and distribution of radio-phosphorus in the blood of, its excretion by, and its therapeutic effect on, patients with polycythemia. *Ann. Int. Med.*, Aug., 1941, *15*, 276–290.

Four robust workmen with recently healed fractures and 6 patients with polycythemia were examined to determine the amount of radio-phosphorus retained by various fractions of the blood, to determine the amount of P^{32} excreted in the urine and feces of normal individuals and patients, and to determine the effect on the blood and clinical findings of P^{32} given for treatment. Tables are presented showing the details of the results.

Greater concentrations of P^{32} are found in the blood and marrow when it is given intravenously than when it is given orally. The amounts retained by the different fractions of the blood varied in different cases but apparently the phosphorus finally reaches the stroma after passing through the hemoglobin fraction. But in general less than 1 per cent of the P^{32} retained by the red blood cells is found in the stroma.

The normal individuals excreted from 25 to 50 per cent of the P^{32} during the six days following its administration, no matter how it was given. The patients excreted less in both urine and feces than the normal individuals.

There was improvement in both the clinical and blood findings of the patients after the giving of therapeutic doses of radiophosphorus. —*Audrey G. Morgan.*

ERF, L. A., TUTTLE, L. W., and LAWRENCE, J. H. Clinical studies with the aid of radio-phosphorus. IV. The retention in blood, the excretion and the therapeutic effect of radio-phosphorus on patients with leukemia. *Ann. Int. Med.*, Sept., 1941, *15*, 487–543.

This article presents a study of 100 cases in which the rate of absorption and excretion of radiophosphorus is considered and its therapeutic effect in patients with lymphatic and myeloid leukemia is shown. Tables are given showing the details of the findings with regard both to absorption and excretion and to therapeutic action.

Radiophosphorus reaches nearly every cell in the body and concentrates in cells with active rates of metabolism. It is retained in greater concentration by circulating leukemic cells than by normal circulating white blood cells. For the first forty-eight hours after it is given, normal individuals excrete radiophosphorus more rapidly than patients with leukemia. The rates after forty-eight hours are about the same in the two groups of cases. Excretion goes on doubtless until all of the radiophosphorus has been excreted.

Radiophosphorus can be given in any way without damage to normal tissues. In these cases it was given orally and intravenously. It is well tolerated by both animals and human beings, and does not cause radiation sickness. It seems to bring about a marked increase of appetite for a few hours after its administration.

The authors found that the frequent administration of small doses (0.5 to 2 mc.) of radiophosphorus to patients with leukemia was better than larger doses at longer intervals. The results as shown by the tables are good enough to justify further use of the method. In 2 cases there was practically complete remission for two years, which is longer than has been reported with other methods of treatment. Both of these patients were still alive when the article was written. It is unfortunate that the lengths of partial and complete remission in all cases treated by various methods have not been recorded in the literature.—*Audrey G. Morgan.*

K'O, Y. K., TU, C. L., and CHAN, B. C. The effect of hard roentgen-rays on intestines of normal dogs fed on inorganic iron compounds. *Surg., Gynec. & Obst.*, Sept., 1941, *73*, 333–340.

Most patients who come for treatment for gynecological cancer show moderate to severe anemia resulting from repeated hemorrhages. Inorganic iron compounds would be good treatment for such anemias, but it seemed possible that the secondary irradiation from the iron particles might injure the intestinal mucosa.

Experiments were performed on dogs to determine whether such was the case. The conditions were made as nearly as possible like those in human beings. Normal dogs were given abdominal irradiation up to a total dose of 2,400 r

without other treatment. They did not show any clinical symptoms or pathological lesions in the small intestine at the end of treatment. Other dogs were given daily doses of ferrous sulphate or ferric ammonium citrate during the irradiation.

The giving of these drugs increased the hemoglobin content of the blood. Neither of the drugs caused any clinical signs of intoxication. Histological examination of the small intestine of the dogs treated with ferrous sulphate showed mild edema and congestion of the mucosa which disappeared completely in eight weeks. In the dogs treated with ferric ammonium citrate there was a greater degree of edema and large hemorrhagic areas in the mucosa. The severe hemorrhagic lesions persisted for more than eight weeks.

The experiments show that ferrous sulphate is valuable in the treatment of anemia from chronic loss of blood and does not injure the small intestine if given during irradiation, while ferric ammonium citrate does irritate the intestinal mucosa and is not to be recommended.—*Audrey G. Morgan.*

SPEERT, HAROLD. Cyclic changes in the mammary gland of the Rhesus monkey; preliminary report. *Surg., Gynec. & Obst.*, 1941, *73*, 388–390.

Attempts have been made to study cyclic changes in the human mammary gland but they have met with considerable difficulty and the reports are contradictory. Such a study of the mammary gland of the rhesus monkey is easier as the gland is smaller and more uniform in structure.

Histological study of biopsy specimens of 9 monkeys at different stages of the menstrual cycle have shown that there are definite changes dependent on ovulation. The characteristic changes are enlargement and increased vascularity of the lobules beginning seven to ten days before menstruation, reaching their height at about the time of menstruation and regressing slowly afterward. They occur only in the cycles in which ovulation has taken place.—*Audrey G. Morgan.*

HOECKER, FRANK E. Evolution of the x-ray tube. *South. M. J.*, March, 1941, *34*, 280–284.

The gradual development of the roentgen tube from the discharge tubes used by Roentgen himself up to the Coolidge tube is described and illustrations given of types of tubes in use from 1897 up to 1915.

Physically a roentgen tube is an instrument which converts electrical energy into roentgen-ray energy when the charges, called cathode rays, strike a fixed object. In the earliest gas tube the charges were given off by a flat disc of metal enclosed in a partially evacuated glass bulb, and roentgen rays were produced when they struck the walls of the bulb. The images were fuzzy and blurred because of the large size of the source of the roentgen rays. The attempt to bring about greater clearness and detail and to produce tubes for therapeutic purposes led to increasing cooperation between physician and physicist. The gas in the early tubes was a necessary evil. The problem was to get rid of the gas without eliminating the stream of electrons, which was the essence of the process of generating roentgen rays. But Edison in 1883 found that electrons are evaporated from the surface of a metal when it is heated to a high temperature. This fact was first utilized practically by Fleming in 1905 when he made the first radio tube. In 1913 Coolidge applied it to the roentgen tube by replacing the concave cathode of the gas tube by a metal filament which could be heated by passing an electric current through it. This eliminated all the disadvantages of the gas tube and made it possible for designers of tubes to work out a multitude of special adaptations for specific purposes.—*Audrey G. Morgan.*

HOPWOOD, F. L. The irradiation of liquids. *Brit. J. Radiol.*, July, 1940, *13*, 221–226.

Since the discovery of neutron and positron in 1932 and of the method of artificial production of radioactive substances the next year much interest has been shown in studying the possible applications of these discoveries to the treatment of disease. In this Silvanus Thompson Memorial Lecture the author discusses and demonstrates experiments in treating proteins, organic and inorganic colloids, electrolytes and water with neutrons. He found that the effect of neutrons on these substances was of the same nature as that of beta rays or gamma rays but that neutrons are more effective than the gamma radium rays.

In irradiating solutions it was found that the primary action of the radiation is probably on the water rather than on the chemical compounds dissolved in it. If this proves true the

activation of water in the human body by irradiation during treatment will be found to be a significant factor in the results of treatment and possibly the predominant one.

It is possible that the chemical estimation of neutrons may prove an alternative to more familiar methods. Curves are given showing the details of the findings discussed.—*Audrey G. Morgan.*

MAYNEORD, W. V. Energy absorption. *Brit. J. Radiol.*, July, 1940, *13*, 235–247.

The author suggests that the effects of radiation depend, not so much on the dose at a particular point, as on the total energy absorbed in the body as a whole and discusses possible ways of determining its value. He also discusses the relationship of the roentgen to energy measurements and suggests the development of a unit which will include the estimation of such quantities as the total energy absorbed. The roentgen is known to be a measure of energy absorption in a given mass of air. He suggests the use of the gm.-roentgen indicating the energy conversion when a dose of 1 roentgen is delivered to 1 gm. of air and refers to the quantity obtained by integrating the dose throughout a given volume or mass as the "integral dose" throughout that region. He works out the formulae for the calculation of the integral doses in gm.-roentgens.

He says that at this stage little can be done except to suggest further investigation but it seems feasible to measure ultraviolet light and long wave length roentgen-ray flux in the common energy-unit. Such a measurement would have great biological and practical interest. Such a method of measurment should also be extended to visible and infra-red radiation.—*Audrey G. Morgan.*

GRAY, L. H., and READ, JOHN. The neutron emission from a generator operating at 300 kV. *Brit. J. Radiol.*, July, 1940, *13*, 248–253.

In a previous paper the authors described an apparatus for the generation of neutron beams of sufficient intensity for biological research. The construction of the generator was supported by the British Empire Cancer Campaign. In this paper they describe three different methods for measuring the neutron emission from this generator: (1) reduction to thermal neutrons and measurement of the radioactivity induced by these neutrons in rhodium; (2) measurement of the intensity of gamma rays emitted when the neutrons of thermal energy combine with protons to form deuterium nuclei, and (3) measurement of the ionization produced by the fast neutron beam in air.

Tables are given showing the details of the results. They show that the agreement between the results of the three methods was satisfactory. The output of the generator is at present equivalent to about 30 curies of radon and beryllium. The energy absorption in tissues at the nearest point to the target at which biological material may be placed is, under good working conditions, about equal to that due to 2 r/min. of gamma radiation.—*Audrey G. Morgan.*

HAPPEY, FRANK. A portable "back-scatter phantom" for X-ray measurements. *Brit. J. Radiol.*, July, 1940, *13*, 254.

The portable back-scatter phantom described is used in conjunction with a Hammer dosemeter for the measurement of roentgen-ray dosage. A photograph is given showing the method of setting up the apparatus for surface dose measurements. This apparatus was introduced to replace the water phantom previously used, as the latter was cumbersome and great care had to be taken to keep water out of the ionization chamber, while this phantom has proved very light and easy to handle. The material used for producing back-scatter is masonite presswood which has the same specific gravity as water and similar scattering properties.—*Audrey G. Morgan.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 FEBRUARY, 1943 NO. 2

CONTENTS

Mediastinal Pleurisy in Infants . . . . ROGER A. HARVEY, M.D. 145

Study of the "Widened" Mediastinum in Children and Pitfalls in Diagnosis . . . . . A. V. SHAPIRO, M.D., AND LEO BELL, M.D. 159

Oil Aspiration Pneumonia . . . MORRIS MOEL, M.D., B.S., AND . . . . . HENRY K. TAYLOR, M.D., F.A.C.P., F.A.C.R. 177

Roentgenologic Considerations in the Diagnosis and Treatment of Diaphragmatic Hernia . . . . . STUART W. HARRINGTON, M.D. 185

Carcinoma of the Head of the Pancreas Demonstrating the New Signs in Roentgen Diagnosis: Case Report . . . . PAUL S. FRIEDMAN, M.D. 197

The Diagnosis of Posterior Protrusion of the Intervertebral Disc . . . . . THOMAS HORWITZ, M.D. 199

Intraspinal Thorotrast . . . . . WILLIAM A. NOSIK, M.D. 214

Pyogenic Osteomyelitis of the Thoracic Spine Presenting as Primary Pulmonary Disease . . . . . HARRY A. SOLOMON, M.D., AND ARNOLD L. BACHMAN, M.D. 219

The Therapeutic Value of Roentgen Treatment in Chronic Asthma . . . . . WAYNE M. HULL, M.D., ... RAY M. BALYEAT, M.D., AND L. K. CHONT, M.D. 227

Radium Therapy as an Aid in the Control of Chronic Otorrhea . . . . ERNEST B. EMERSON, JR., M.D., AND ANDREW H. DOWDY, M.D. 234

Radon Treatment . . . . . STEPHEN KLINGHOFFER, PH.D. 240

Effect of Roentgen Irradiation on Capillary Permeability and Inflammation in the Skin of the Rabbit . . . . R. H. RIGDON AND HOWARD CURL 250

Editorial
Roentgenologic Examination and, not or, Gastroscopy 259

Society Proceedings, Correspondence and News Items 261

Book Reviews 265

Abstracts of Roentgen and Radium Literature 268

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publishers.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 FEBRUARY, 1943 No. 2

MEDIASTINAL PLEURISY IN INFANTS*

By ROGER A. HARVEY, M.D.
ROCHESTER, NEW YORK

INTRODUCTION

VARIATIONS in the contour of enlarged thymus gland shadows are so numerous that the significance of distinctly atypical shadows is frequently overlooked. Pleurisy does occur in the anterior superior mediastinal area, and gives shadows similar to, but differing from, the thymus gland in many respects. Pleurisy involving the mediastinal and adjacent visceral pleurae is usually difficult to detect by physical signs and routine roentgen procedures. Most of the diagnostic difficulties can be accounted for by the depth and density of the mediastinum, its normal variations in contour, and the variety of pathological processes which can occur within or adjacent to it.

LITERATURE

The roentgenological aspects of this form of pleurisy in infants have received little attention in the literature. The original observations were all reported in foreign journals, and include the reports of Pincherle[6] in 1925, Reyher[7] in 1928, Saupe[9] in 1933, Engel and Schall[3] in 1933, and Gefferth[4] in 1939. Shanks, Kerley and Twining[10] in their recent English "Text-Book of X-Ray Diagnosis" published in 1938 have referred to a previous report[3] for coverage of this subject in infants. Pertinent findings in the foreign reports will be discussed later in this paper. This form of pleurisy has received little recognition in this country, and this is probably the result of (*a*) English abstracts of the original papers not including graphic material; (*b*) the low mortality associated with this form of pleurisy preventing postmortem confirmation of reports in the literature; (*c*) the lack of well known differential features between this type of pleurisy and thymus gland enlargement, and (*d*) the poor roentgen technique in infant cases.

The various forms of mediastinal pleurisy with and without effusion which have been described in the literature have been assembled in diagrammatic form in Figure 1. All of these sites and forms are duplicated by many disease processes and structural abnormalities. Area 2 is of greatest interest in this paper. Figure 2 shows some of the locations of these pleurisies and effusions in another plane at mid-chest level. The contours are schematic, and can vary in amount and shape in different diseases and levels in the chest.

PATHOLOGICAL ANATOMY

The mediastinum separates the right and left pleural cavities and contains vital structures connecting with the neck and

* From the Department of Radiology of the University of Rochester, School of Medicine and Dentistry, and the Strong Memorial Hospital, Rochester, New York.

abdomen. It is covered laterally with pleura which is continuous with costal and diaphragmatic pleurae. The sternum forms its anterior boundary, and the thoracic vertebral column forms its posterior boundary. Within the mediastinum are such structures as the heart, great vessels, trachea, bronchi, esophagus, nerves, thymus gland, lymphatic trunks, and nodes. Chronic and

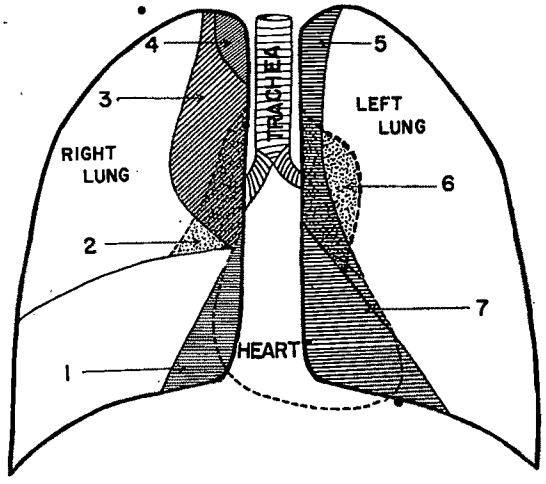


FIG. 1. Schematic drawing of the thorax showing the seven areas of localization of mediastinal pleurisy reported in the literature.

acute infections frequently involve many of these structures, and occasionally the limiting sternum or spine. These infections may remain localized to one structure, spread to an adjacent one, or give rise to diffuse involvement of the mediastinal area—all with some possible degree of pleural involvement. Infections of the neck region may extend downward to involve the mediastinum. Subdiaphragmatic infection is sometimes associated with diaphragmatic or mediastino-diaphragmatic pleurisy and adjacent pneumonitis.

Infections within the lungs frequently give rise to associated processes in the adjacent visceral pleura, and in the bronchial and tracheobronchial lymphatic systems.

Thus, pleurisy involving the mediastinal and/or visceral pleurae can arise from pathological changes within the lungs, within the mediastinum, within the lungs and mediastinum simultaneously, or from primary processes in the neck or abdomen with extension to the mediastinal area.

DIFFERENTIAL DIAGNOSIS

Although the differential diagnosis in cases of suspected superior mediastinal pleurisy is mainly between pleurisy and thymus gland enlargement, there are many other conditions which may be confused. Among these are:

1. Partial atelectasis of the lung.
2. Pneumonic infiltration.
3. Stasis in the superior vena cava by pressure from an elevated bronchus.
4. Enlarged hilar nodes.
5. Infections of the thymus gland.
6. Tumors of the thymus gland.
7. Dilated left auricle.
8. Retrocardial aneurysm.
9. Paravertebral abscess.
10. Spondylitis deformans.
11. Esophageal diverticulum.
12. Dilated esophagus.
13. Scoliosis.
14. Pericardial fat tab.
15. Ganglioneuroma of the vagus nerve.
16. Tumor of the pericardium.

PRESENTATION OF CASES

Case 1 illustrates unilateral thymus gland enlargement, and is included for comparison, differentiation, and discussion. The re-

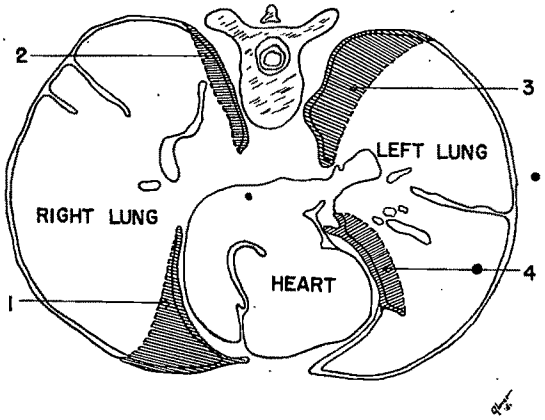


FIG. 2. Schematic drawing of a transection of the thorax at mid-chest level showing some of the possible localizations of mediastinal pleurisy in this plane.

maining 8 cases demonstrate forms of mediastinal pleurisy which have been encountered in patients under one year of age. Although 7 of these cases were thought to show thymus gland enlargement, there are many features in each case which would contradict such a diagnosis. The group is presented to define further the thymus problem.

Case I. E. R. R. was a ten week old male with a history of episodes of restlessness, hypertonicity, and irritability since birth. The physical findings were normal. Roentgenograms of the chest taken on October 28 and November 6, 1940 (Fig. 3) revealed right-sided thymus gland enlargement. Deep roentgen therapy (100 r) was administered to the anterior mediastinum on November 7 with the following factors: 200 kv., 25 ma., 0.5 mm. Cu, 1.0 mm. Al, and 50 cm. target-skin distance. The thymus shadow was reported absent from roentgenograms taken one week and also three months after the treatment. The infant has remained asymptomatic since treatment.

Case II. M. M. was a six week old female who had received mineral oil orally and had had irritability, feeding difficulties, and cyanotic spells several times a day for three weeks. On admission to the hospital her temperature was normal, white blood count was 9,600, and tuberculin skin test was negative. A chest roentgenogram taken on November 8, 1940 (Fig. 3) revealed pneumonia and an angular paramediastinal density on the right side. She was given 100 r of deep roentgen therapy to the anterior mediastinum on November 11, 1940. She was discharged from the hospital on November 27 slightly improved, although a chest roentgenogram still showed a pneumonic consolidation and the angular density.

This patient was seen many times in the clinic because of cough and noisy respirations during the following two months, and she was readmitted to the hospital on March 6, 1941, with a flare-up of the pneumonic process. The patient was given another 100 r of deep roentgen therapy to the anterior mediastinum on March 24, 1941. The pneumonic process gradually disappeared but there has been no significant change in the right paramediastinal angular shadow as judged by roentgenograms taken on March 27, April 4, May 29, and October 21, 1941. Repeated cultures have revealed no "causative" organisms, and a chronic pneumonitis on a lipoid aspiration basis is thought to explain the pneumonic processes.

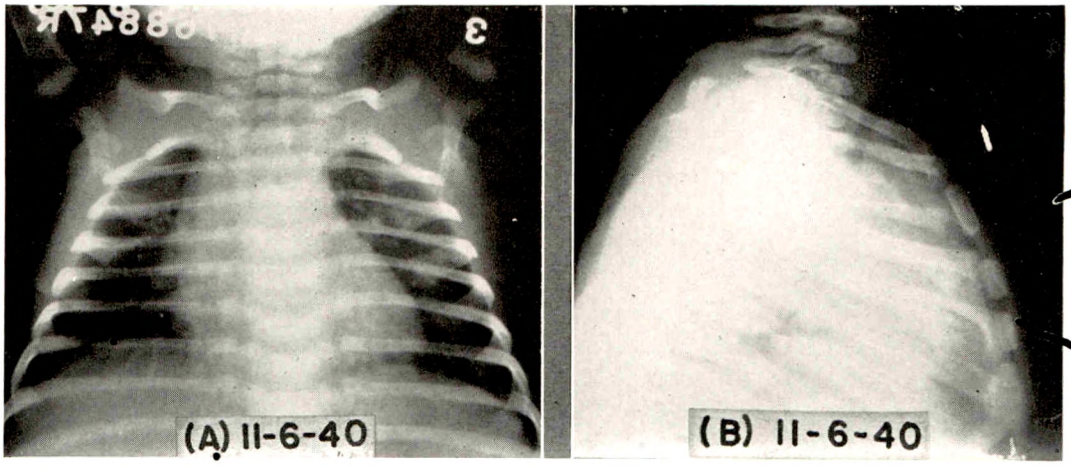
Case III. L. S., a male infant, was normal for the first two months of life. He was then admitted to another hospital in the city with signs of an upper respiratory infection, white blood count of 15,000, slight fever, and a negative tuberculin skin test. A roentgenogram of the chest was interpreted as congenital atelectasis of part of the right upper lung with reaction about the area. He was discharged from the hospital after ten days but returned to that clinic for the next month because of persistent cough. He was then taken to another institution where another chest roentgenogram was also interpreted as atelectasis.

Three months later he was first seen in this clinic with a history of chronic cough, and a more recent complaint of wheezing and grunting respirations during feeding. There had been no recognized fever or cyanosis since the original episode. Physical examination revealed dullness anteriorly to the right of the mediastinal border but no change in breath sounds. A chest roentgenogram taken on February 19, 1941 (Fig. 4) closely resembled those previously taken elsewhere. The patient was admitted to this hospital on February 22 with vomiting, diarrhea, a temperature of 39° C., white blood count of 14,200, and a negative tuberculin skin test. A chest roentgenogram taken on February 24 showed no change from the previous one. The patient remained a diagnostic problem, but was discharged from the hospital on March 1, 1941. He was brought back several times because of a fever and cough, and subsequent chest roentgenograms have revealed a gradual alteration in the shape and a final disappearance of the paramediastinal shadow previously observed.

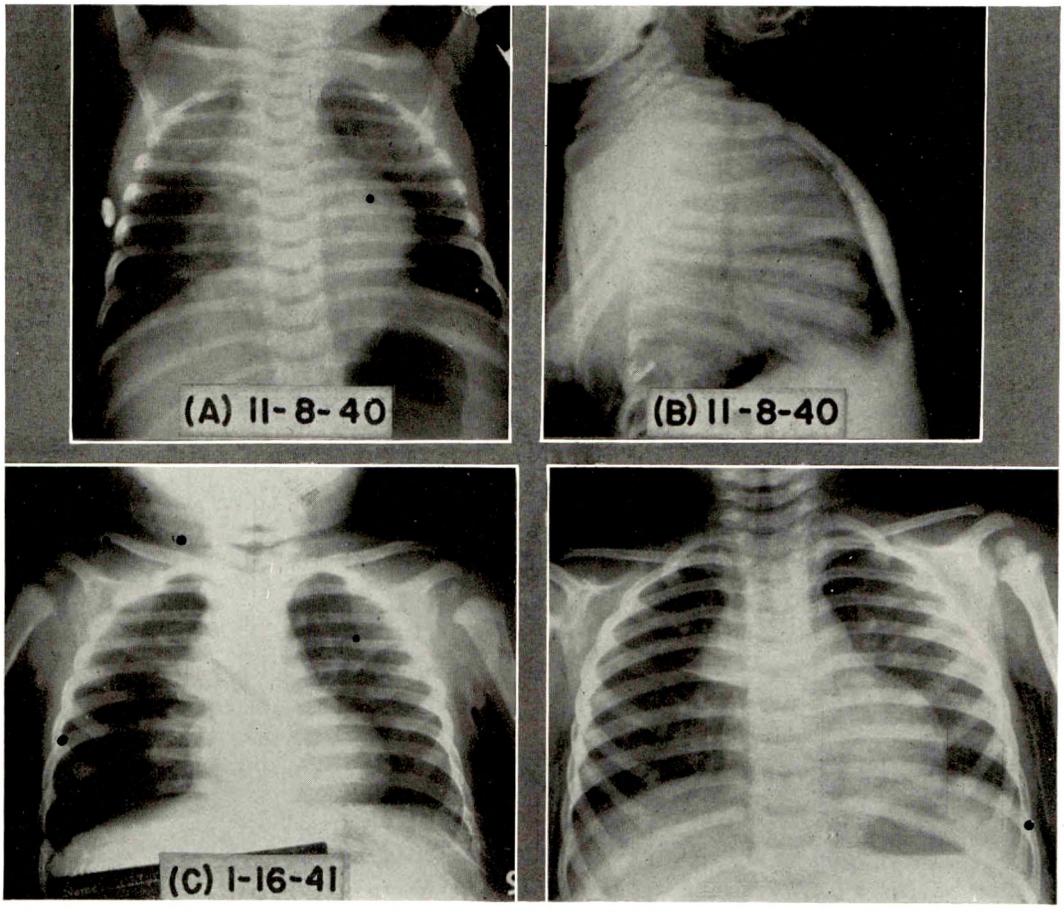
The patient was readmitted to the hospital on May 21, 1941, with signs of right upper lobe pneumonia, white blood count of 21,000, and Type VI pneumococci in the gastric washings. Sulfathiazol was effective in combatting the pneumonia, and he was discharged from the hospital on September 12, 1941.

Recently he has received an autogenous vaccine from his nasopharyngeal flora, and has been found allergic to chocolate. A bronchial asthma is thought to exist.

Case IV. W. R. was a normal male infant at birth, and he was well for three weeks. At that



Case I



Case II

Fig. 3. *A*, Case 1. An anteroposterior view of the chest showing right-sided thymic enlargement which extends below the right interlobar fissure to cap the upper cardiac shadow. *B*, Case 1. A lateral view showing increase in density in the superoanterior portion of the chest, and posterior deviation of the tracheal shadow which was persistent during roentgenoscopy and is accentuated here by the respiratory phase.

Comment: Subsequent examinations following roentgen therapy to the anterior mediastinum revealed

time he developed pneumonia in the left lung, and was admitted to the hospital on February 12, 1941, in an acutely ill state. His temperature was 38.3° C., white blood count was 36,000, and the tuberculin skin test was negative. Roentgenograms of the chest revealed a left central pneumonia and emphysematous changes in the upper and lower left lung areas (Fig. 5). Sulfathiazol had little effect. Roentgenograms of the chest during the next month showed very little change, bronchoscopy revealed "extrinsic pressure on the left bronchus as from adjacent atelectasis," and lung puncture cultures showed *Staphylococcus aureus haemolyticus*. The patient developed a small left hydrothorax, but about five weeks after admission, the pneumonic process appeared slightly less in extent. March 31, 1941, deep roentgen therapy, 100 r, was given to the left anterior chest, and 150 r was given to the left posterior chest on April 1, 1941. On April 2 he coughed up several mouthfuls of foul smelling green pus, and from this point on the left lung rapidly cleared except for the emphysematous changes. He did well for the next four months but then developed persistent cough. A roentgenogram of the chest taken on September 12, 1941, revealed a new triangular area of density along the right mediastinal border, and a persistence of emphysematous areas in the left lung. He was next seen on October 22, 1941, with more cough. A roentgenogram of the chest showed a decrease in the size of the angular density and considerable increase in the prominence of the pulmonic markings around that area.

Case v. D. W. was a male infant, two months old when he was admitted to the hospital with jaundice. A routine chest roentgenogram revealed a patchy increase in markings in the right upper lung field. Rotation in positioning was so extreme that the mediastinal area could not be satisfactorily studied. The tuberculin skin test was negative. The jaundice cleared gradually, and the patient was discharged three weeks after admission.

Three months later he was readmitted to the hospital with persistent cough and difficult breathing. Physical examination was not remarkable. The white blood count was 24,000, tuberculin skin test was negative, and a chest roentgenogram showed an angular shadow extending laterally from the right border ofthe mediastinum and pneumonic changes in the left lung (Fig. 5). Cultures showed a Type XIII pneumococcus. He improved with symptomatic treatment and was discharged from the hospital after ten days with his cough still present.

One month later he was seen in the clinic with a history of severe cough since discharge from the hospital. Another roentgenogram of the chest showed little change from the previous one.

The cough gradually decreased during the next five months. Roentgenoscopy of the chest at this time revealed the angular shadow to be considerably smaller.

Case vi. M. R. was born prematurely, grew satisfactorily for more than five months, and had had mineral oil administered orally for several weeks. She was admitted to the hospital as a feeding problem. Physical examination revealed a pneumonic process in the right upper lung, and a slight fever. The white blood count was 12,000, tuberculin skin test was negative, and a roentgenogram of the chest taken on September 29, 1941, revealed pneumonia in the right upper lung field and an angular density along the right upper mediastinal border (Fig. 6). Cultures revealed no "causative" organisms. The pneumonic signs cleared rapidly. A roentgenogram of the chest taken on discharge from

---

absence of the angular shadow in the anteroposterior view, and a return of normal radiolucency in the superoanterior portion of the chest in the lateral view. The tracheal shadow appeared straight in the lateral views.

Case II. *A*, An anteroposterior view of the chest showing pneumonic densities in the right upper and lower lung fields, an angular density extending laterally from the mediastinum and limited inferiorly at the interlobar fissure region, and tracheal shift to the right.

B, lateral view showing a slight radiolucency beneath the sternum area, and an anterosuperior mediastinal chest density limited sharply at the interlobar fissure inferiorly.

C, posteroanterior view showing the angular density, persistence of increased lung markings, and tracheal deviations to the right.

D (right lower, 10-21-41), posteroanterior view showing a persistence of the angular density in spite of two previously administered deep roentgen therapy treatments.

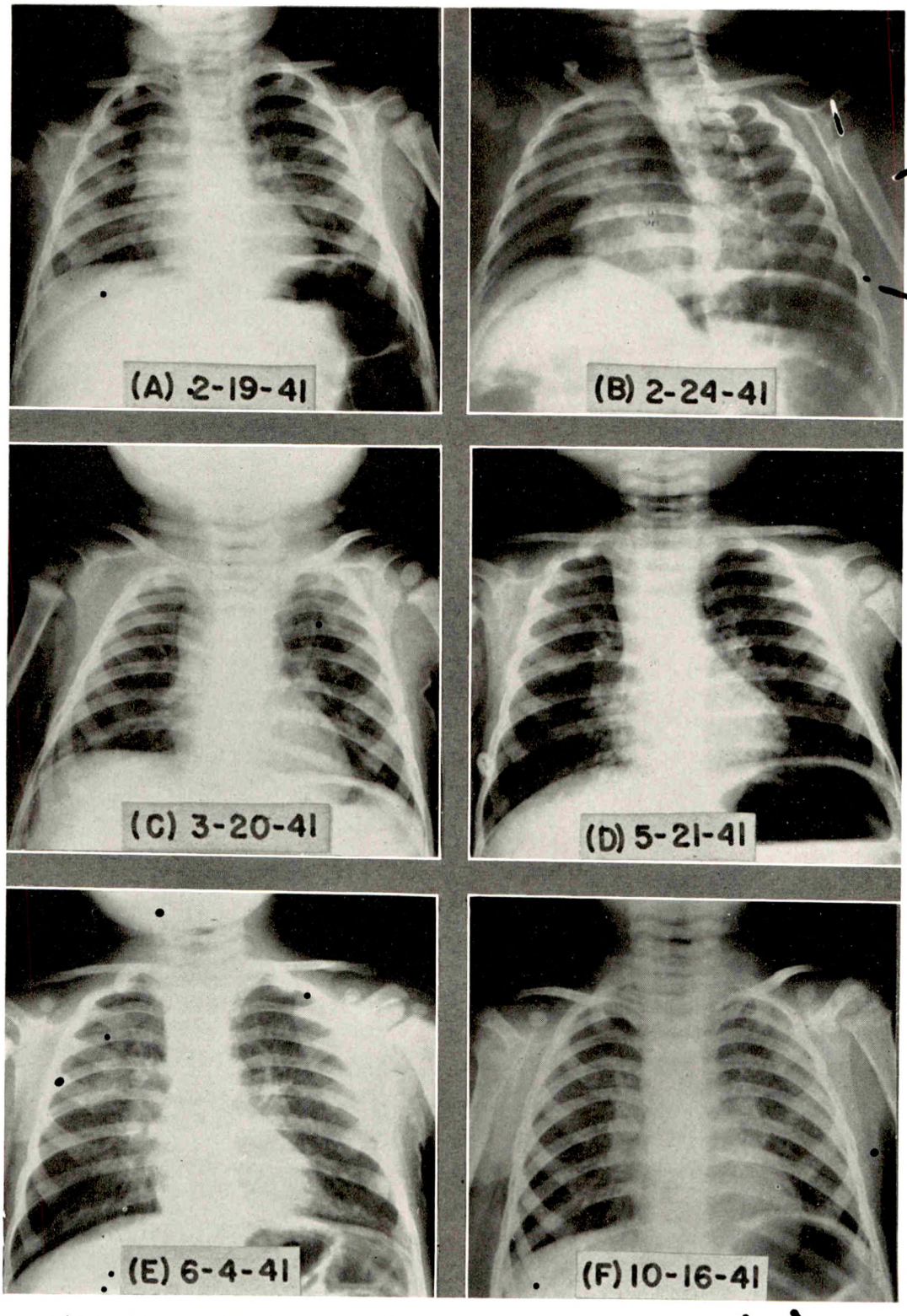


FIG. 4. Case III. *A*, posteroanterior view of the chest showing tracheal deviation to the right, an angular paramediastinal shadow on the right with sharp inferior limitation at the interlobar fissure, and increased lung markings.

the hospital on October 9, 1941, revealed clearing of the lung fields, but persistence of the right paramediastinal density. She was readmitted to the hospital on December 30, 1941, with a recurrence of the pneumonia in the same area of the lung, but the right paramediastinal density noted in the previous examination was no longer visible. Cultures again failed to reveal a "causative" organism. The pneumonic process has shown little tendency to subside during the past five weeks, and lipoid pneumonitis is suspected.

CASE VII. J. R., a six month old male mongolian idiot, was admitted to the hospital on February 13, 1939, with measles and bronchopneumonia from which he recovered. He was discharged from the hospital on March 12, 1939. He was readmitted to the hospital during the next year with Type XVII pneumonia on one admission, and Type XIX pneumonia on another admission. On March 8, 1940, he was admitted with a Type IV pneumococcal involvement of the left lower lobe of the lung. Roentgenograms also showed widening of the mediastinal shadow, and irregularity of both superior mediastinal borders which was thought to be due to effusion localized in this area (Fig. 6). Subsequent roentgenograms on March 11, 1920, showed a clearing of the pneumonic process and alteration in the configuration of the mediastinal shadow. The patient succumbed several months later from further pneumonic processes. An autopsy was refused.

CASE VIII. M. C. was born prematurely but grew normally for two months. Suddenly she developed a cough, fever, vomiting, and on the second day severe respiratory distress occurred. She was admitted to the hospital in a moribund condition, with a temperature of 36.5° C., a white blood count of 41,000, hemoglobin of 7.9 grams, an enlarged heart, and signs of pneumonia at the left lung base. A chest roentgenogram showed an enormous increase in the heart shadow, an angular density projecting laterally from the right mediastinum into the interlobar fissure, and increased lung markings in the left lung (Fig. 6). She was started on sulfathiazol and nasal oxygen, but died seven hours after admission.

The autopsy revealed a small amount of clear amber fluid within the abdominal cavity, 15 cc. of clear amber fluid within the pericardial sac, a 55 gram heart, moderate hypertrophy of the myocardium, marked thickening of the endocardium, numerous fibrous adhesions along the middle and lower right mediastinal pleural border, fibrous adhesions in the central portion of the right interlobar fissure, and mild pulmonary congestion. Microscopic study showed fibrous thickening of the endocardium, numerous lymphocytes in the region of the pleural adhesions, and pulmonary congestion. Chemical studies failed to establish glycogen storage disease.

CASE IX. M. M., a two month old male inveloped an ear infection which required a six day hospitalization. He remained free from symptoms for three weeks, and was then readmitted to the hospital on March 6, 1939, with fever, a white blood count of 15,300, physical and roentgenographic signs of pneumonia with Type XXII pneumococci in the sputum, and a negative tuberculin skin test. He became afebrile with sulfapyridine therapy. The patient received 100 r of deep roentgen therapy to the anterior mediastinum on March 14, 1939, for suspected concurrent right thymus enlargement, and was discharged from the hospital free of symptoms on March 17, 1939.

For the next seven months he was followed in another clinic for asthma, the chief symptom being wheezing at night. He was readmitted to

---

B, oblique view showing the anterior position of the paramediastinal density. Note the relation to the interlobar fissure.

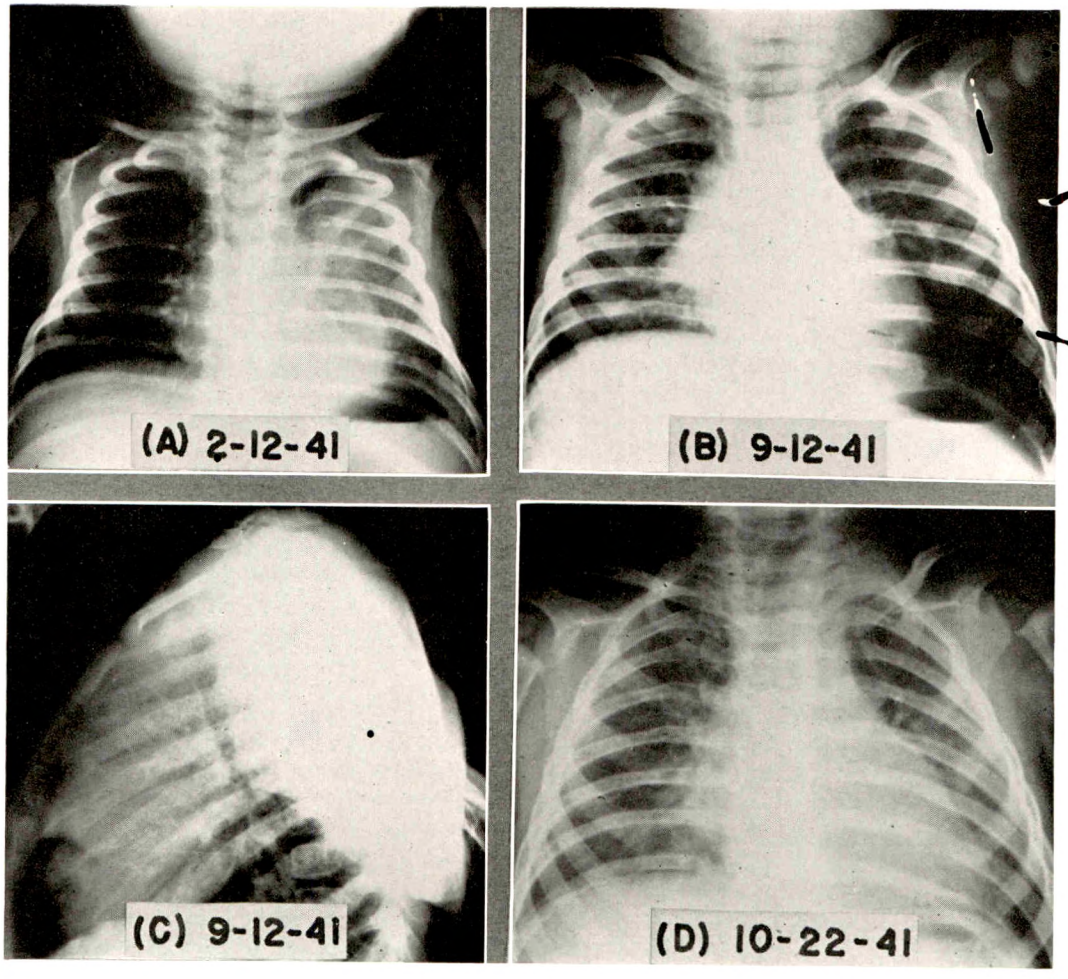
C, posteroanterior view showing change in shape of the density and persistence of increased markings.

D, posteroanterior view showing further alteration in the shape of the density, and increased lung markings particularly in the central region. Note inferior angle of the density and its relation to the medial portion of the interlobar fissure.

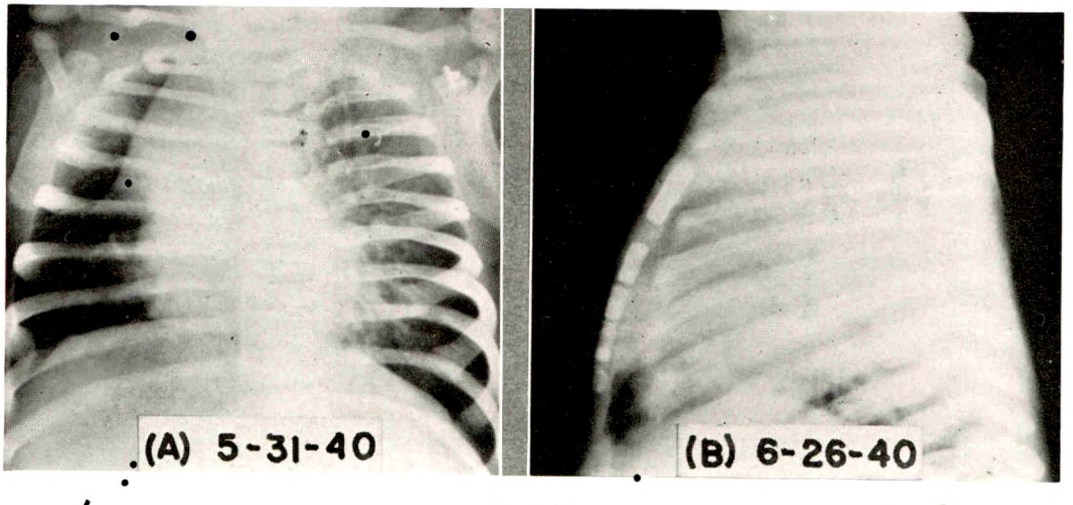
E, posteroanterior view showing a pneumonic process in the right upper lung field, absence of the previously described angular density, and increase in density of the interlobar fissure.

F, posteroanterior view showing bilateral increase in central lung markings, and continued absence the angular density.

Comment: The course of this case and the illustrations closely resemble a case of "questionable thymus gland enlargment" presented by Gerstenberger.[5]



Case IV



Case V

Fig. 5. Case iv. *A*, posteroanterior view of the chest showing pneumonic and emphysematous changes in the left lung field.

the hospital with fever, white blood count of 10,300, roentgenographic signs of left upper lobe pneumonia, and the persistence of right-sided angular paramediastinal density. Type XXII pneumococci were numerous in the cultures. Sulfapyridine therapy was effective in combatting the pneumonia.

Figure 7 is a schematic representation of the various configurations of the pleurisies presented by the preceding cases.

DISCUSSION

Although only one of these cases presented as illustrations of mediastinal pleurisy has had a postmortem examination, they all closely resemble proved cases presented by other authors. This form of pleurisy has been encountered exclusively in young children. Pincherle[6] has reported finding 30 cases of mediastinal pleurisy in 2,000 routine roentgen chest examinations in young children, or an incidence of 1.5 per cent. The cases described in this paper and 2 more recently observed would suggest a similar low incidence here.

Clinically there is no single or group of symptoms that would permit a definite diagnosis of mediastinal pleurisy, even with effusion, without a roentgenogram of the chest. Cough is the most common symptom, 6 of the 8 cases reported here having had a history of prolonged cough. Usually these cases are pneumonic in origin, frequently showing recurrences of pneumonic infection, and some cases being more specifically designated as "pleuropneumonia."[8] The pneumonic recurrences affect the related lobes of the lung more often than lobes on the opposite side of the mediastinum from the original pleurisy. Five of the cases just reviewed had several recognized pneumonic episodes, 2 cases had a single known pneumonia simultaneously with or prior to the appearance of the pleural process, and 1 case had no known pneumonic history. Physical findings are usually related to the pneumonic processes rather than to the pleurisy or effusion. In Case III, definite widening of the anterior mediastinum was detected by percussion, and this is the only case in this group in which variation in mediastinal size or contour was suspected prior to roentgenography. Mineral oil had been administered orally to 2 of the cases in this series, and the lung changes in Case II and Case VI were thought to be due to lipoid pneumonitis. The tuberculin skin test was repeatedly negative in all of the cases in this series.

The course of these cases is relatively benign as evidenced by the low mortality in this series to date. The 2 deaths so far in this group of 8 cases give an inaccurate mortality rate of 25 per cent, because Case VIII died of cardiac disease primarily, and Case VII was complicated by mongolian idiocy. Reyher[7] reported 1 death in 26 cases of mediastinal pleuritis. His fatal case was a three month old infant, and the process was tuberculous.

The treatment of these cases has been symptomatic except for the pneumonic recurrences which have had sulfonamide therapy. Diagnostic or therapeutic aspiration of possible fluid present has been suggested, but this was not resorted to in any

---

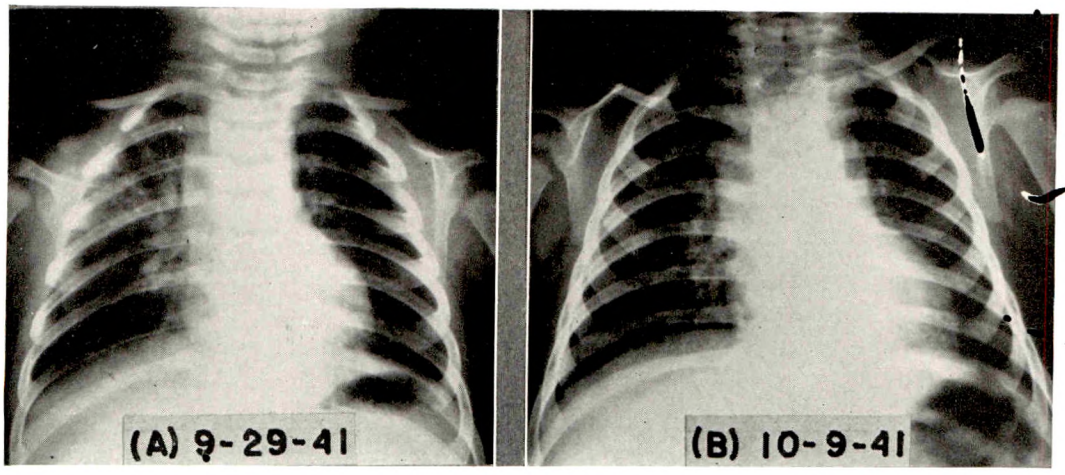
B, posteroanterior view showing the degree of clearing of the left lung field, persistence of emphysema, and the appearance of a new triangular density along the right mediastinal border.

C, lateral view showing the anterior distribution of the previously noted density, and its sharp inferior limitation at the interlobar fissure.

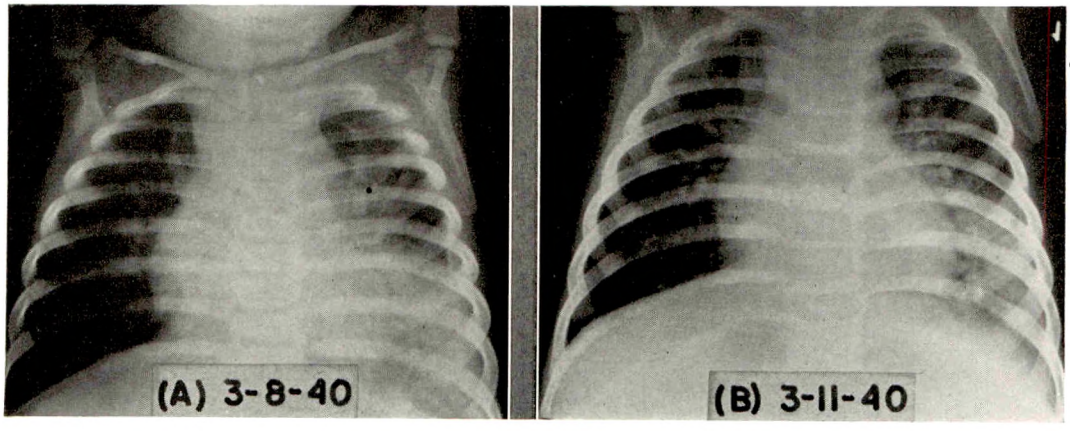
D, posteroanterior view showing reaction in the previously noted area of angular density.

Case V. *A*, anteroposterior view of the chest with some rotation. The angular density off the right mediastinal border is continuous inferiorly with the interlobar fissure. Pneumonia is present in the left lung field.

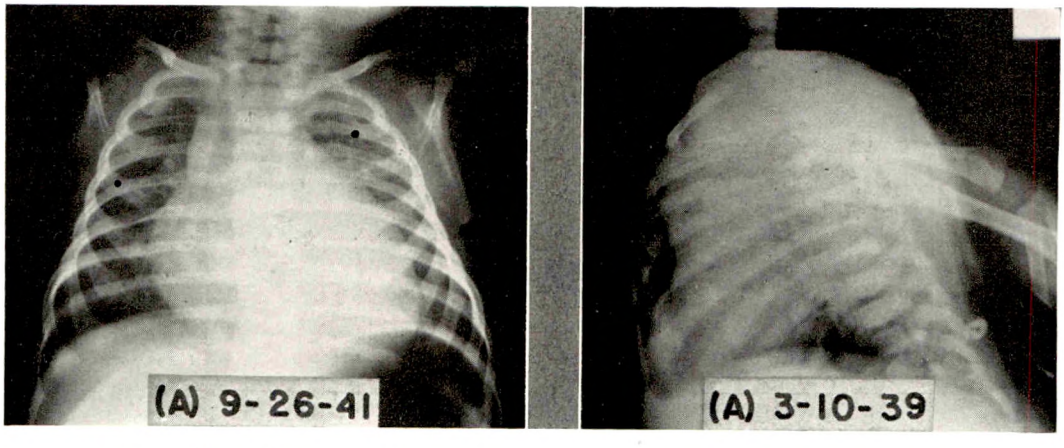
B, lateral view showing the anterior location of unusual density, its sharp inferior border, and its decreasing intensity superiorly.



CASE VI



CASE VII



CASE VIII CASE IX

FIG. 6. Case VI. *A*, posteroanterior view of the chest showing pneumonia in the right lung field, and a right paramediastinal density associated inferiorly with the interlobar fissure. *B*, posteroanterior view showing clearing of the pneumonia and slight change in the contour of the paramediastinal density.

of these cases. Therapeutic drainage would be in order in the presence of empyema. Roentgen therapy directed to the anterior mediastinum has not permanently altered the appearance, or significantly shortened the course of the disease in the 2 cases in which it was tried (Cases II and IX).

The pathological changes occurring in this type of case have common findings, as judged by recorded autopsy findings.[3] When fluid is present it is serofibrinous, and the associated pleurisy is of fibrinous or fibrous character which serves to localize the fluid. A residual thickened pleura persists for an undetermined time after disappearance of the fluid. Bigler[1] has reported finding fibrous adhesions frequently along the mediastinal pleura at autopsy on children without previously recognized pleurisy from the clinical standpoint. In general, the predominance of right-sided lesions has been explained by the larger number and immediate subpleural location of the right tracheobronchial and bronchial lymph nodes as contrasted with the fewer and deeper placed nodes on the left side. Of all the infections which could involve these anterior nodes, tuberculosis is apparently rare. Buckley[2] examined 115 tuberculous cases with known mediastinal involvement and found only 2 cases with evidence of this infection in the anterior group of nodes.

Bacteriologically, the following organisms were recovered from the sputum, gastric washings, or lung punctures during the acute pneumonic stages in 5 of the cases reported in this paper:

Type VI pneumococcus (1 patient)
Type XIII pneumococcus (1 patient)
Types IV, XVII, and XIX pneumococcus, a different single type being recovered during each separate illness (1 patient).
Type XXII pneumococcus recovered during two separate illnesses (1 patient).
Staphylococcus aureus haemolyticus (1 patient)

Of the remaining 3 cases, 2 failed to show "causative" organisms, and the pneumonic processes were thought to be due to lipoid aspiration; the third never had a known pneumonic infection.

Postmortem cultures of fluid present are reported to be sterile, except when pneumococcal, staphylococcal, or tuberculous empyema occurs, the latter being found more frequently in older patients.

The roentgen recognition of this form of pleurisy is important, but the criteria which are used to distinguish it from unilateral thymus gland enlargement are not generally known. This form of mediastinal pleurisy with or without effusion is characterized by or associated with:

1. A sharp lateral margin.
2. Ends in an inferior angle of less than 90° and in relation with or near the interlobar fissure.
3. Usually unilateral and more often present on the right side than on the left side.
4. Frequent inflammatory changes in the adjacent lung parenchyma.
5. Increase in the width and density of the interlobar fissure shadow.
6. Greatest density is inferior in the lateral projection.

Case VII. *A*, anteroposterior view of the chest showing pneumonia in the left lung field, bilateral widening of the superior mediastinal shadow, and a double angular contour of the left border of the mediastinum. *B*, anteroposterior view showing decrease in the pneumonic process, and a change in contour of the left mediastinal border.

Case VIII. *A*, posteroanterior view of the chest showing enormous cardiac enlargement, increased markings in the left lung field, and a small angular density extending from the mediastinal area laterally into the interlobar fissure.

Case IX, *A*, lateral view of the chest showing a sharply marginated density in the superior and anteromedial aspect of the chest. Note the clear space in the retrosternal area.

Comment: The remainder of the roentgenograms of this case are not reproducible at this time, but the posteroanterior views do show a right sided angular paramediastinal density similar to Case II (*C*) in Figure 3.

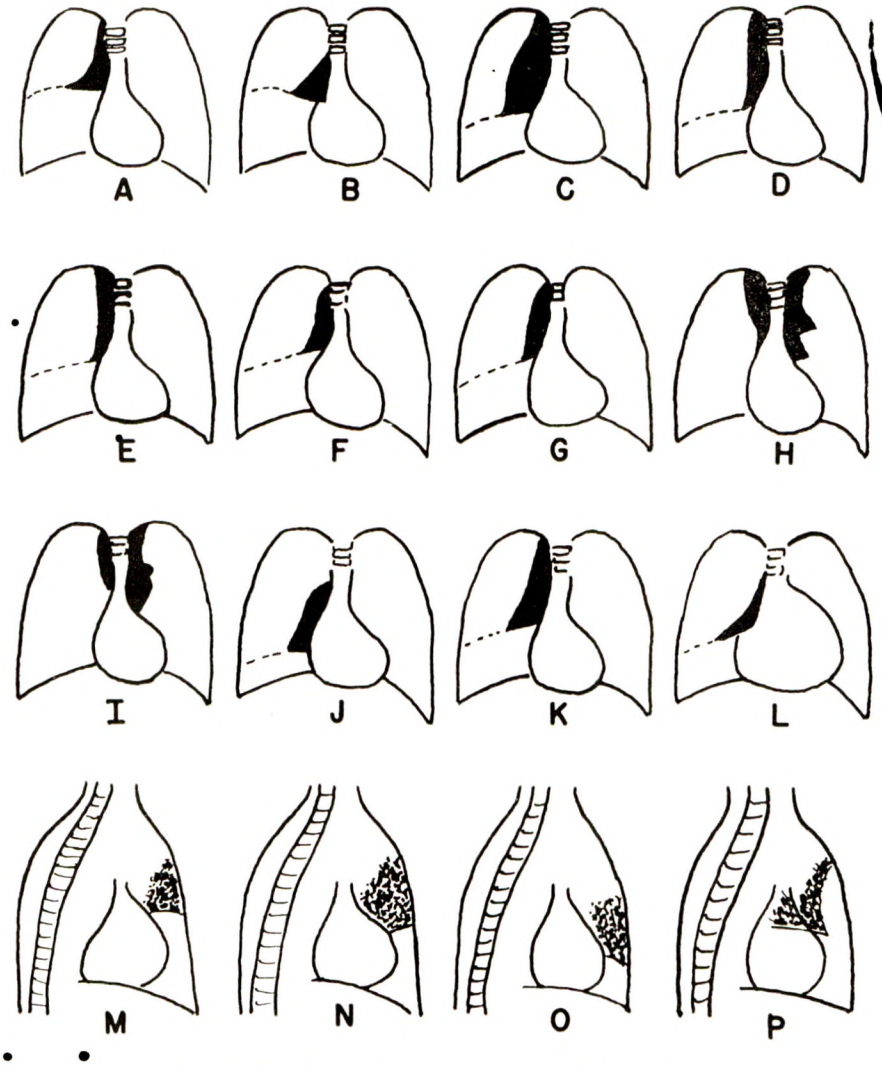


FIG. 7. A schematic representation of the areas of pleurisy demonstrated in Cases II through IX.

Drawing	*Case*
A	II
B	II
C	III
D	III
E	III
F	VI
G	VI
H	VII
I	VII
J	IV
K	V
L	VIII
M	II
N	IV
O	V
P	IX

7. The density may be anywhere between the anterior and posterior boundaries of the pleural space in the lateral projection.
8. No tracheal deviation or distortion in the lateral projections. Persistent lateral deviation to the affected side in the postero-anterior views in 2 cases in this series.
9. Minimal changes in the size and contour of the density during quiet or labored respiration.
10. No significant reduction in size after small doses of roentgen therapy.

In contrast to the preceding criteria, significant thymus gland enlargement is characterized by:

1. A larger shadow which overlaps part of the cardiac shadow.
2. Rounded corners, usually 90° or more.
3. Considerable change in contour with respiration and crying.
4. More often bilateral, although asymmetries and unilateral forms are well known.
5. Variable degrees of tracheal and esophageal deviation or compression in one or both planes. This point is still widely disputed in the literature.
6. Always anterior and superior in lateral projections.
7. Decreases in size after small doses of roentgen therapy.

It is possible to have both pleurisy and thymus gland enlargement simultaneously. Improvement in symptoms following a roentgen treatment without evidence of much reduction in the angular shadow is possible in that thymus tissue present and obscured by the pleural density could be reduced so as to allow shift or redistribution of any fluid present. Occasional reports of roentgen resistant thymus glands should be checked for possible misinterpretations of the findings.

The greatest source of error arises from poor positioning or alignment in roentgenography. Slight rotation of the patient may completely obscure portions of the mediastinal border. Low positioning of the tube accentuates these angular deformities and in 2 of these cases, the residual thickened pleura cast a solid triangular shadow from this angle. Correct alignment in these same cases showed only linear shadows representing thickened pleura in the central interlobar fissure area. This thickening was a residual characteristic of all the cases which cleared of their major density during the period of observation.

CONCLUSIONS

1. Atypical appearing thymus gland shadows and cases of so-called roentgen resistant thymus gland should be reappraised with mediastinal pleurisy foremost in the differential considerations.

2. Mediastinal pleurisy is found in 1 to 2 per cent of routine roentgen chest examinations in children under one year of age.

3. Infants having prolonged, atypical, or repeated pneumonic symptoms should be examined for the existence of mediastinal pleurisy.

4. Pleurisy of this form was associated with pneumococcal infections of the lungs in four cases in this series, and with suspected lipoid pneumonitis in two cases. Frequent recurrences of pneumonic infection were noted.

5. Treatment of the cases reported was symptomatic except for specific therapy of the initial or recurrent pneumonic processes.

6. Diagnostic or therapeutic aspiration for any fluid present was not attempted in this series.

7. Roentgen therapy directed to the mediastinal area in two cases did not shorten the course of the process.

8. Residual linear pleural thickening in the central interlobar fissure region was noted after clearing of the pleurisy, and it appeared as a solid triangle when poor alignment occurred in roentgenography.

The author wishes to express his gratitude to Dr. Stafford Warren, Dr. George H. Ramsey, Dr. Andrew Dowdy, Dr. Joseph Green, Dr. Sidney Larson, Dr. John MacMillan, and Dr. A. Gordon Ide for advice, assistance, and discussion of the various diagnostic problems presented by these cases; also to Dr. Dowdy for giving roentgen therapy to two of

these cases; and to the Department of Pediatrics for its cooperation and interest in this study.

REFERENCES

1. BIGLER, J. A. Interpretation of roentgenograms of the chest in children based on observations at necropsy. III. Diseases of the lungs, of the pleura and of the mediastinum. *Am. J. Dis. Child.*, 1930, *39*, 91–106.
2. BUCKLEY, R. C. Tuberculosis of the anterior mediastinal lymph nodes. *Am. Rev. Tuberc.*, 1928, *17*, 583–585.
3. ENGEL, S., and SCHALL, L. Handbuch der Röntgen-Diagnostik und -Therapie im Kindesalter. Thieme, Leipzig, 1933, pp. 257–270.
4. GEFFERTH, K. Über einen Fall vom beiderseitigen Pleuritis mediastinalis superior anterior. *Monatschr. f. Kinderh.*, 1939, *81*, 128–131.
5. GERSTENBERGER, H. J. The factor of the position of the diaphragm in roentgen-ray diagnosis of enlarged thymus. *Am. J. Dis. Child.*, 1921, *21*, 534–545.
6. PINCHERLE, P. Radiological study of mediastinal pleurisy. *Radiol. med.*, 1925, *12*, 277–300. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *14*, 371–372.
7. REYHER, P. Mediastinale Pleuritis im Kindesalter. *Arch. f. Kinderh.*, 1928, *83*, 276–286.
8. RIVIERE, C. An unusual variety of pleurisy in children. *Practitioner*, 1904, *73*, 381–392.
9. SAUPE, E. Pleuritis mediastinalis superior oder Thymushyperplasie? *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1933, *48*, 314–320.
10. SHANKS, S. C., KERLEY, P., and TWINING, E. W. A Text-Book of X-Ray Diagnosis. H. K. Lewis, London, 1938, Vol. I, pp. 418–420.

VOL. 49, NO. 2

STUDY OF THE "WIDENED" MEDIASTINUM IN CHILDREN AND PITFALLS IN DIAGNOSIS*

By A. V. SHAPIRO, M.D., *and* LEO BELL, M.D.
NEW YORK, NEW YORK

INTRODUCTION

THE investigation of which this paper is the result grew out of the realization that a number of infants and children were being kept as patients at this institution solely because of roentgenographic evidences of "widened mediastinum" or "enlarged" mediastinal and tracheobronchial lymph nodes. In some cases, the children had been hospitalized for one to three years (Cases I, II, III) with no evidence of active tuberculous involvement of the lung parenchyma, with negative sputa, negative gastrointestinal examinations and no further clinical evidence of disease other than a positive tuberculin reaction, which is representative of a healed as well as an active infection. Some of the patients previously had had definite clinical and roentgenographic evidence of pulmonary tuberculosis but, long after the parenchymal lesion had completely resolved, discharge from the hospital was delayed because of apparent tuberculous mediastinal lymphadenitis.

During this period, the children had been roentgenographed in the horizontal position, a practice which is still prevalent in most institutions. The probable reason for the extensive use of this faulty technique is that it is apparently easier to place an infant or small child on the table on top of the cassette, and then make an exposure. For the past seven years, however, the senior author had been roentgenographing the chests of all infants and children at another institution in the upright position, and during this time, had often had occasion to note the marked variation in the width of the mediastinal shadow when films taken in the horizontal and upright positions were compared. Because of this experience, upright chest roentgenography was instituted as a routine procedure in the Pediatric Pavilion at Sea View Hospital.

As a result, a considerable number of children have been discharged because of sudden restitution of the mediastinal shadow to normal. It must be emphasized that this return to the normal of the mediastinum occurred, not by virtue of healing or shrinkage of enlarged mediastinal or paratracheal nodes, but solely because of an altered or improved technique of roentgenographic examination.

Although the work herein described has been primarily in the field of "initial infection" or "childhood" tuberculosis, the subject has a very much wider application. Indeed, it is our feeling that the interpretation of any chest roentgenogram of the infant or young child is subject to grave error unless the film has been taken according to a correct technique and unless the various factors that may alter the size and appearance of the heart and mediastinal shadow are fundamentally understood. What these several factors are will be brought out and elaborated upon in the body of this communication, under the head of "Discussion."

The proper interpretation of what constitutes a normal mediastinal shadow on the roentgenogram has long been the subject of much discussion and investigation. Krause[16] in 1924 wrote, "Enlargement of the mediastinum or chronic mediastinitis runs through x-ray reports, especially those of children's examinations, like a song, with a monotony that makes one wonder whether mediastinal changes are not the normal in the young." The reason for this statement and for the confusion it depicts is that most chest films are made in the

*From the Department of Radiology, Sea View Hospital, Staten Island, N. Y.

horizontal position. If children's chests were routinely roentgenographed in the upright position, there would be no occasion for a statement of this character. The interpretation of what constitutes a normal mediastinum would then be no more difficult in children than in adults.

The technique of upright roentgenography in infants and children is by no means a new concept, though it has never been generally adopted. Remer and Belden,[25] as far back as 1927, employed this technique but in their method it was necessary for both the patient and cassette to be held by an attendant. It often requires a high degree of acrobatic skill to hold an uncooperative crying child or infant properly, without having to hold both cassette and patient. Pancoast and Pendergrass[23] later devised a chair with a built-in cassette holder which in principle is not unlike our device. This was an adaptation of their encephalographic technique and was employed by them chiefly for roentgenography of the neck and thymus. In 1931, one of us (A.V.S.) had occasion to see at the Willard Parker Hospital, a cassette holder for upright chest roentgenography built by Kohn and Koiransky,[15] and it was this apparatus which served as a model for the modified and improved device which we built. The device will be described later but it may be said at this point that with it, all infants and children, including the newborn, can be roentgenographed with much greater ease in the upright than in the horizontal position. Wood[28] also described a "frame for holding infants upright" in 1934, which serves essentially the same purpose. An apparatus for upright roentgenography has also been described by Engel and Schall.[8]

Although roentgenologists and pediatricians alike are generally cognizant of the differences in the size of the heart and mediastinum that exist with upright and horizontal roentgenography, in many cases the knowledge is of an academic rather than practical character, since horizontal chest roentgenography for children is still carried out in most institutions. In discussing the matter with several experienced clinicians, the answer is usually, "Yes, we know, it is nothing new," but nevertheless, they are almost invariably surprised when shown roentgenograms of the same child, made at the same time but with the two different techniques (upright and horizontal).

It is almost superfluous to point out the great benefits to both the patient and the hospital if the period of hospitalization can be significantly reduced. This applies particularly to institutions for the care of tuberculous children, because such cases are often kept for several years. As regards the patient, once having arrested his disease, he is best out of the hospital since he is unquestionably less subject to further exposure and leads a more normal life in a home environment that harbors no open case of tuberculosis. With hospital budgets strained as they are and with long lists of patients waiting for admission, the advantages for the hospital in reducing the period of institutional care are obvious.

In institutions for the hospitalization of tuberculous children, their stay will without doubt be shortened if the mediastinum appears normal rather than widened due to faulty technique. In general hospitals not limited to tuberculosis, the avoidance of incrorrect diagnoses by adoption of an upright technique is too advantageous to require extended comment.

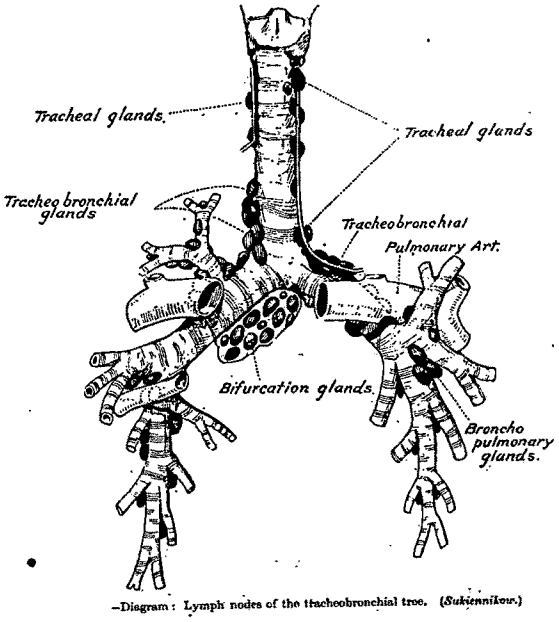
ANATOMY

Generally speaking, the anatomy of the mediastinum is fairly well known to most of us, especially as it appears on the roentgenogram. However, the appearance of the mediastinal shadow may undergo marked variation, depending on the technique and manner in which the roentgenograms are taken. In order to understand the reason for this and to better appreciate its importance and application to the interpretation of children's chest roentgenograms, it is worth while reviewing the anatomy of the mediastinum.

The mediastinum lies between the two pleural sacs and is bounded anteriorly by the sternum

and posteriorly by the vertebral column. It is then subdivided into the superior, anterior, middle and posterior mediastinum, the contents of each being:[6]

1. The *superior*, bounded by the sternum anteriorly, the first four thoracic vertebrae posteriorly, laterally by the mediastinal pleurae, and below by an imaginary line drawn from the inferior border of the fourth thoracic vertebra to the inferior border of the sternum, its contents being the aortic arch and its three great branches the innominate veins and part of the superior vena cava, trachea, esophagus, thoracic duct, phrenic, vagi and cardiac nerves, the thymus, and left recurrent nerve.
2. The *middle*, containing the heart, pericardium, phrenic nerves and associated vessels.
3. The *anterior*, containing fibro-areolar tissue which lies between the pericardium and sternum and the lymph glands.



—Diagram: Lymph nodes of the tracheobronchial tree. (*Sukiennikow.*)

FIG. 1

4. The *posterior*, bounded by the pericardium and vertical portion of the diaphragm, anteriorly; posteriorly, by the last eight thoracic vertebrae; and laterally, by the mediastinal pleurae containing the descending thoracic aorta, intercostal branches, azygos, hemiazygos, and accessory hemiazygos veins, thoracic duct, esophagus and the two vagi.

Roentgenographically, the mediastinal and heart shadow borders are also known. The right border ordinarily is formed by the right auricle below, ascending arch of aorta, the superior vena cava and innominate vein (when dis-

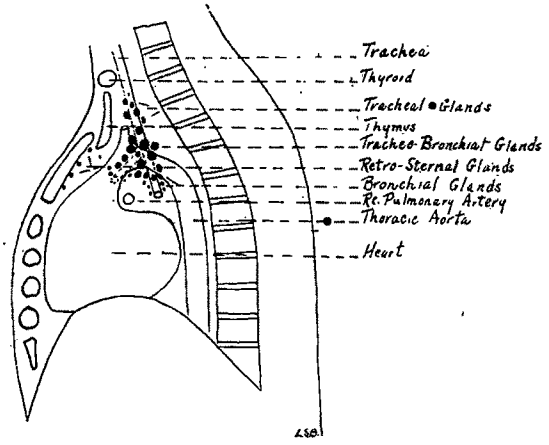


FIG. 2. Left sagittal section of infant thorax.

tended as in the horizontal position). The left border from below upward is formed by the left ventricle, left auricular appendage, the pulmonic conus and the aortic knob. According to Margolies,[18] the left border of the supra-aortic portion of the superior mediastinum is formed by the soft tissue shadows of the left common carotid and subclavian arteries.

The trachea lies in the midline and bifurcates at the level between the third and fifth dorsal vertebrae. The aorta lies in the middle of the mediastinum and it passes upwards and turns backwards, passing down behind the heart. The shadow of the thymus is triangular, its base overlapping the base of the heart, especially the auricles. The mediastinal lymph glands lie along the trachea, paratracheally and along its bifurcation (Fig. 1). Bigler,[3] in his careful dissection of the lung, found that lymph nodes were present in every hilum, the larger nodes at the hila and the smaller towards the periphery. He concluded that the normal nodes do not cast shadows on the roentgenogram and that nodes in the hilum or in intrapulmonary tissue, caseous or inflammatory, cannot be recognized if they do not contain calcium, or are large enough to encroach on the pulmonary fields, or are embedded in air-bearing parenchyma, the contrast of which renders them

visible. In relation to the sagittal diameter of the chest, the trachea, its glands, the veins (superior vena cava and azygos group) and the branches of the aorta in this area lie closer to the anterior surface of the body than to the posterior. This is illustrated in Figure 2, and the anterior position of these structures has an important bearing on the roentgenographic technique adopted, as will be brought out later.

METHOD

The procedure adopted in this study was as follows: 25 patients ranging in age from newborn to eleven years were selected and 10 of these had eight successive roentgenograms taken in the following positions:

1. Anteroposterior horizontal, at end of expiration
2. Anteroposterior horizontal, at end of inspiration
3. Posteroanterior horizontal, at end of expiration
4. Posteroanterior horizontal, at end of inspiration
5. Anteroposterior upright, at end of expiration
6. Anteroposterior upright, at end of inspiration
7. Posteroanterior upright, at end of expiration
8 Posteroanterior upright, at end of inspiration

In the remaining 15, films only in the upright and horizontal posteroanterior positions, in the same phase of respiration, were taken. All films were taken at 36 inch distance and 1/30 second exposure, only the voltage being varied to suit the thickness of the chest being roentgenographed. Thus, all films are directly comparable since the factors of distortion and magnification are constant. Case VII (Fig. 21–28) illustrates the eight positions utilized.

Only 7 of the 25 cases are included in this article, since they illustrate the salient points, and only in Case VII are all eight roentgenograms presented. In the remaining cases, to conserve space, only the most significant roentgenograms are shown. In addition to the 25 cases included in the special study, there were a great many isolated cases in which the anteroposterior horizontal and posteroanterior upright were available for comparison. The variations present between the two roentgenograms in some of the cases were so great as to cause doubt whether both roentgenograms were of the same patient. This, of course, was checked and verified.

As a result of study in the various upright and horizontal positions, it was almost invariably found that the roentgenograms made in the posteroanterior upright position at the end of inspiration were the most satisfactory and gave the least distorted and least misleading views of the heart and mediastinum. If, in addition, a method of synchronizing the exposure with the same phase of the cardiac cycle is employed, successive roentgenograms on different days are absolutely comparable, particularly in regard to heart size and shape. We have often noted two chest roentgenograms of a stereoscopic pair which showed marked changes in size and configuration of the heart. Obviously, in such a case one roentgenogram was taken in systole and the other in diastole.

DISCUSSION

Changes in the size and appearance of the mediastinal and heart shadows on the roentgenogram may be produced by various factors, among which the most important are position (whether horizontal or upright), the effect of gravity, the phase of respiration and the phase of the cardiac cycle. The changes so produced are neither trivial nor unimportant, since they may be responsible for serious mistakes in diagnosis. Thus, we have seen chest roentgenograms that were entirely normal diagnosed at various times as hypertrophied thymus, childhood tuberculosis, congenital or acquired valvular heart disease, enlarged heart and even bronchopneumonia, where none existed. These mistakes are easily made unless one understands the effect of the above mentioned factors in producing the alteration in the roentgenogram.

Effect of Position and Gravity. Great variation in the size of the mediastinum has long been recognized and ascribed to change in position.[22-25]. In the cadaver, Cunningham[6] states that owing to the weight of the heart, the anterior mediastinum is increased and the posterior mediastinum reduced in the anteroposterior depth. From this, it can be inferred that the mediastinal structures can move in anteroposterior direction because of available space and the force of gravity. In the supine position (anteroposterior) the mediastinal structures tend to drop posteriorly. Because of the bony character of the vertebrae, there is no yielding space posteriorly and, as a result, the structures spread laterally, pushing the lungs before them. The amount of lateral displacement, though not great, is appreciable, as the roentgenograms demonstrate.

In the prone (posteroanterior) position, the mediastinal structures move anteriorly. Again, the mediastinum tends to spread laterally, but owing to the soft compressible fibro-areolar tissue and the space in the anterior mediastinum, it more nearly approaches the sternum and the lateral displacement is minimal. Thus, it may be stated that in the horizontal position, the posteroanterior (prone) view will produce a narrower mediastinal shadow than the anteroposterior (supine) view. This is due also to another important factor which holds true for both the horizontal and upright positions, namely that the trachea, its lymph nodes, heart and vessels all lie closer to the anterior surface of the body than to the posterior (Fig. 2). Thus, when the cassette is placed against the anterior part of the chest, as in the posteroanterior view, these structures lie closer to the film and undergo less distortion and magnification than if they were farther from the film as in the anteroposterior position.

Still another important rôle in increasing the width of the mediastinal shadow in the horizontal position can be ascribed to the abdominal organs. These tend to push up the diaphragm, thus shortening the vertical diameter of the thorax and causing lateral expansion of the mediastinal structures, including the heart. Again, in the horizontal position, widening is added to by distention of the large blood vessels (superior vena cava and innominate vein on the right, and subclavian vessels on the left).

In the upright position, all these factors produce the opposite effect. The blood vessels empty, the abdominal viscera drop, removing their pressure on the diaphragm, and the mediastinum tends to recede inferiorly. In doing so, the lateral displacement is minimized and the mediastinal shadow is correspondingly narrowed. It may thus be stated that all other factors being constant, the posteroanterior upright position is the one calculated to produce the narrowest and least misleading shadows of the heart and mediastinum on the roentgenogram.

Effects of Respiration. The mechanism of repiration in changing the size of the mediastinal and heart shadows has had various explanations. Groedel and Dietlen[11] are of the opinion that descent of the diaphragm produces inspiratory narrowing and the ascent produces expiratory widening. Holzknecht and Hofbauer[12] found widening throughout inspiration (which is contrary to other reports and our own findings). Dietlen admits a widening in early inspiration due to sudden filling of the superior vena cava and right auricle as the result of suction effect. This mechanism has been studied to a great extent by Manges,[17] who also demonstrated that the crying effort influences the size of the heart and mediastinum. With normal breathing, the thoracic cavity grows smaller and the diaphragm rises as the air is gradually expelled during the repiratory phase.

As the thoracic cavity diminishes in length with the rising diaphragm, the heart is lifted and tilted so that the apex is swung farther to the left and the base farther to the right. The transverse diameter of the heart, therefore, increases during this phase and the projected cardiac shadow occupies a proportionately greater area at expiration than it does at inspiration. He further

showed that the reverse is true as far as the heart shadow is concerned, during the forced expiration incidental to the crying effort (Valsalva effect). The narrowed glottic chink offers a decided resistance to the column of air as the infant forcibly contracts the chest to increase the volume of sound. The intrapulmonary pressure is raised as a result and the heart swings on its long axis, the apex coming forward and the base backward. Its narrower diameter is therefore presented; the projected area is lessened for the greater part of this phase and is only broad for a moment, at the extreme end of expiration. Thus, in the crying child, unless one makes the exposure at this final instant of expiration, he will find the transverse cardiac diameter less than at inspiration, even though the chest has narrowed and the diaphragm has risen.[9]

During inspiration, as noted above, the heart and mediastinum, because of pressure changes and rotation of the heart, actually appear smaller. In addition, the thoracic cavity is enlarged and the pulmonic fields become wider so that the heart and mediastinal shadows appear even narrower in proportion. It is a common experience to observe the measurable differences in the size of the heart and mediastinum when roentgenograms, taken a few minutes apart, in inspiration and expiration, are compared (Fig. 19 and 20).

Another important point not directly related to this study merits brief consideration. During expiration, the lungs and particularly the bases are compressed by the rising diaphragm and contraction of the chest wall. In the horizontal position, the abdominal organs further displace the diaphragm upward, so that rather marked diminution in aeration of the lung bases may appear on the roentgenogram. The small pulmonary vessels become distended and the lung markings become prominent. These seen on end, against the background of relatively hypoventilated lung, may produce an appearance simulating bronchopneumonia (Fig. 23).

Often the cardiac shadow shows marked differences in the same individual on successive roentgenograms taken in the same position and the same phase of respiration. It is not an uncommon experience to find pronounced changes in the heart size and shape on the two films of a stereo pair, taken an instant apart. It is obvious that the cardiac cycle and the changes produced by systole and diastole must be considered in explaining this variation. This was studied by McPhedran and Weyl[20] in 1927. As a result, they synchronized exposures with the various phases of the cardiac cycle and were thus able to obtain roentgenograms showing the differences in the size of the heart. By synchronizing their exposures with the late diastole, they were able to eliminate artefacts and secure finer detail. We have on numerous occasions observed marked changes in the size of the heart which could have been due only to changes in the phase of the heart cycle, since examinations were made in the same position and phase of respiration. When, in addition to this factor, we consider the changes in heart size and shape that may occur due to the horizontal position and to phase of the respiratory cycle, it becomes apparent how unreliable cardiac measurements, particularly in children, may be if roentgenograms are taken at random with an unstandardized technique. The size and shape of the heart should be judged only in comparison with previous or subsequent teleroentgenograms made in the upright posteroanterior position, in inspiration, and using short exposures (1/10 sec. or less). If, in addition, means are available to synchronize the exposure with a particular phase of the cardiac cycle, the likelihood of error is reduced to a minimum. Common sense indicates, therefore, that in viewing roentgenograms not made under standard conditions, exact cardiac measurements are a delusion, and considerable latitude should be allowed in the judgment of cardiac enlargement or pathologic alteration of contour.

Relation of Mediastinal Shadow to Thymus. Many of the previous studies of the

mediastinum were made in relation to its bearing on the question of thymic enlargement. This is easily understood when it is considered that a so-called widened mediastinal shadow has often been mistakenly diagnosed as "hypertrophied thymus." We believe that no such diagnosis should be based on mere widening of the mediastinal shadow, especially if the roentgenogram has been taken only in the horizontal position. We have seen shadows that were diagnosed on horizontal roentgenograms as representing thymic enlargement, completely or almost completely disappear on roentgenograms taken in the upright position.

There is little doubt that many children have been unnecessarily given roentgen therapy for thymic enlargement because of errors in diagnosis due to roentgenograms made in the horizontal position. The width of the supposed thymic shadow (actually normal mediastinum) also varies with the phase of respiration, being wider on expiration and narrower at the end of inspiration, as well as being influenced by whether the infant is quiet or crying and the type of crying, i.e. regular or irregular. It was Pancoast[22] who wisely set up the criteria that "unless there are clinical evidences and lateral x-rays of the neck to show definite buckling of the trachea, it is impossible to make a diagnosis of enlarged thymus." To this can be added that no such diagnosis should be based solely on horizontal roentgenograms. Roentgenoscopic study, too, yields valuable information and its importance should not be overlooked. Correct positioning of the patient and roentgen tube is also essential in taking roentgenograms to demonstrate the thymus. The thymic shadow may appear either to one side or the other by incorrectly focusing the central ray or by failure to place and maintain the patient in the exact center of the cassette.[3] The thymic shadow may become greatly diminished in size or it may entirely disappear when the head is held in extreme dorsal flexion.

REPORT OF CASES

Case 1. D. M., colored female, aged two, who two months before admission developed a mild non-productive cough and slight evening fever. The child was taken to Board of Health for routine check-up and as a result was admitted to the hospital on February 7, 1938. The past history was essentially negative and the contact was found to be the father who died of pulmonary tuberculosis in December, 1937.

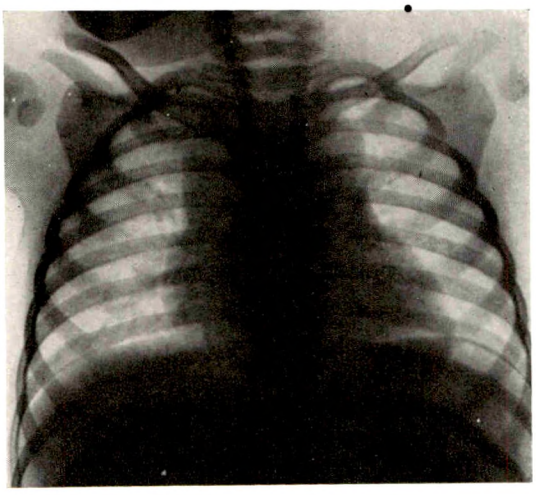


Fig. 3. Case 1. Admission roentgenogram, February, 1938, reveals bilateral widening of the mediastinal shadow.

On admission, physical examination revealed a well developed, fairly well nourished two year old colored female. The cervical glands were enlarged to a little more than twice their normal size. The heart was essentially negative. The lungs revealed slightly increased breath sounds on the right. The tonsils were hypertrophied and cryptic. The Pirquet test was positive, with tuberculides seen around the reaction. The liver edge was palpable 1.5 cm. below the costal margin.

Laboratory Data. Urine negative except for few leukocytes. Wassermann reaction negative. Sputum, gastric contents and feces negative for tubercle bacilli. Weight 26 lb., temperature 99–101° F., erythrocyte sedimentation rate 30 mm. per hour. Roentgenogram of chest revealed widened mediastinum (Fig. 3).

Course. By October, 1938, there were no further elevations in temperature, patient was gaining weight and the erythrocyte sedimenta-

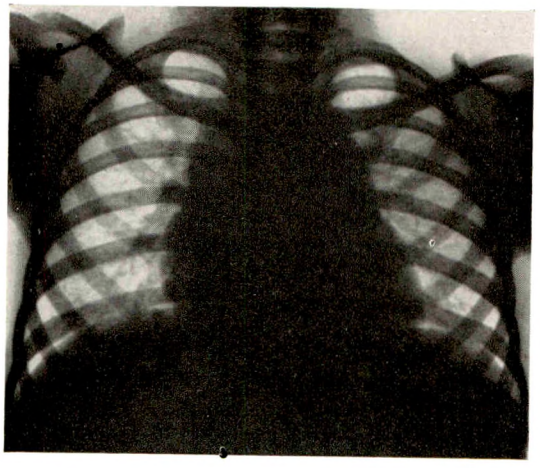


FIG. 4. Case 1. Expiratory posteroanterior horizontal roentgenogram three years later (March 15, 1941) still shows marked increase in mediastinal and heart shadows. Patient might have been hospitalized indefinitely on the basis of these findings.

tion rate was normal (8 mm.). The gastric findings remained negative and the chest roentgenogram apparently still showed enlarged mediastinal glands. Though the patient's general condition consistently improved, with no signs or laboratory evidence of clinical activity, she was kept in the hospital because of supposed enlargement of the mediastinal nodes until December, 1940, when an upright posteroanterior roentgenogram was made and a striking reduction of the mediastinal and heart shadow to normal became evident. As a result, the patient was discharged but remained in the hospital until April 2, 1941, because of difficulty in finding a home for her.

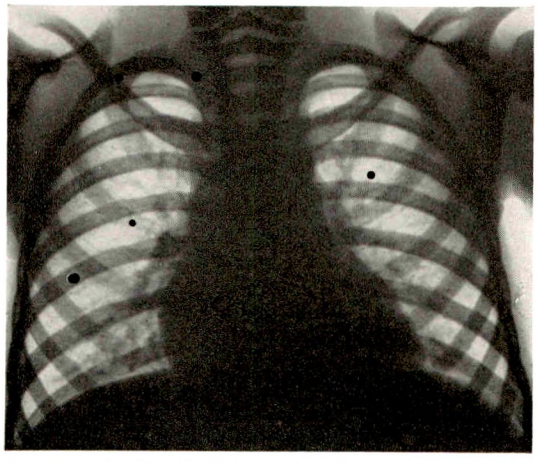


FIG. 5. Case 1. Expiratory posteroanterior upright roentgenogram, taken at the same time as Figure 4. Note decrease in width of mediastinal shadow and change in cardiac configuration as a result of upright position.

Comment. This patient obviously entered the hospital with the initial infection tuberculosis as evidenced by the elevated temperature, sedimentation rate, positive Pirquet test at age of two years and roentgenographic evidence of enlarged mediastinal nodes. By October, 1938, however, all

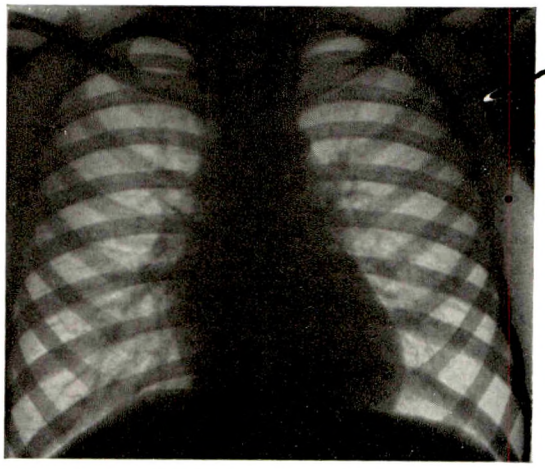


FIG. 6. Case 1. Inspiratory upright posteroanterior roentgenogram, taken at the same time as Figure 4. Mediastinal shadow is narrower than in Figures 4 and 5. Heart size smaller and shape entirely normal. Patient was discharged because of normal chest findings on this roentgenogram.

clinical and laboratory evidence of activity had disappeared and the patient might have been discharged except for apparent enlargement of the mediastinal nodes as seen on the roentgenogram. Figures 4, 5 and 6 were all taken at the same time on March 15, 1941, and illustrate the striking differences in the width of the mediastinum and configuration and size of the heart, solely as a result of different roentgenographic technique.

This case is but one of many similar examples that might be used to illustrate the unnecessarily prolonged hospitalization because of simulated widening of the mediastinal shadow. A point worth mentioning

is that if apparently enlarged mediastinal glands persist unchanged and show no calcium deposition for periods between one and two years, then one should seriously doubt that the mediastinal shadow is due to enlarged caseating tuberculous nodes. In from one to two years, such nodes should either break down or shrink and show evidences of calcification.

Case II (Fig. 7 and 8). M. T., colored male, aged five, was admitted on January 2, 1940, because of the discovery of a positive Mantoux reaction by a local physician and a roentgenogram of the chest made by the Board of Health which was interpreted as showing mediastinal tuberculosis. The contact in this case was the grandmother.

On admission, examination showed a well developed and somewhat emaciated five year old colored male. The heart and lungs were essentially negative except for some diminished breath sounds in left axilla. The weight was 34½ lb. and blood chemistry, urine, blood count and Wassermann reaction negative. The erythrocyte sedimentation rate was 13 mm. per hour, and sputa and gastric contents negative for tubercle bacilli.

Course. Patient began to gain weight soon after admission and physical findings remained essentially negative. Admission roentgenogram showed some thickening of the left pleura which cleared in two months, and widening of the superior mediastinal shadow, especially to the right. Weight gain continued and general condition improved, and patient remained afebrile, with exception of a short period during which a Vincent's infection of the mouth occurred. In spite of the negative physical and laboratory findings, the roentgenographic finding of widened mediastinum persisted (Fig. 7) and patient was therefore kept in the hospital until February, 1941, when an upright roentgenogram was taken (Fig. 8). This showed a striking change of the mediastinal shadow to normal and, as a result, patient was discharged.

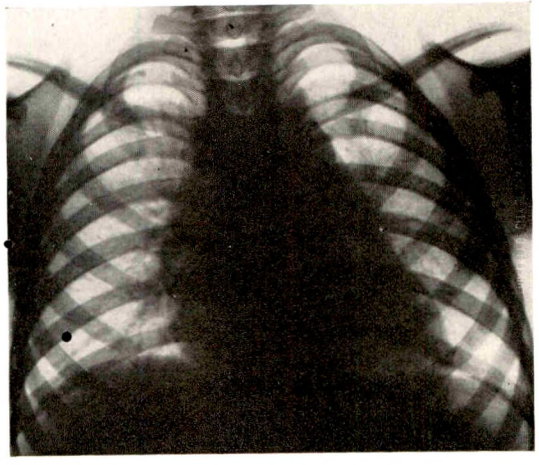


Fig. 7. Case II. Expiratory posteroanterior horizontal roentgenogram (April 15, 1941). Note wide superior mediastinal shadow (more striking in larger original roentgenogram).

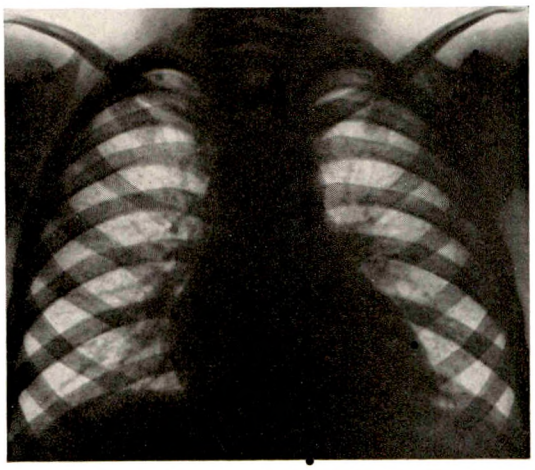


Fig. 8. Case II. Expiratory posteroanterior upright roentgenogram, taken at the same time as Figure 7. The mediastinum, heart and lungs are normal. Patient was discharged on the basis of this roentgenogram.

Comment. Here, too, a patient was hospitalized for one year longer than necessary because the roentgenogram showed apparent widening of the mediastinum. It must be borne in mind that the change between Figure 7 and Figure 8 is much more striking in the larger original roentgenograms than in the smaller reproductions. This applies to all other illustrations shown.

Case III (Fig. 9, 10 and 11). J. O., colored male, aged three, was admitted to Metropolitan Hospital in May, 1937, because of routine Board of Health check-up, and was transferred to Sea View Hospital on February 4, 1939. At Metropolitan Hospital, he was found to have enlarged hilar nodes. On admission to Sea View Hospital, examination showed a well developed,

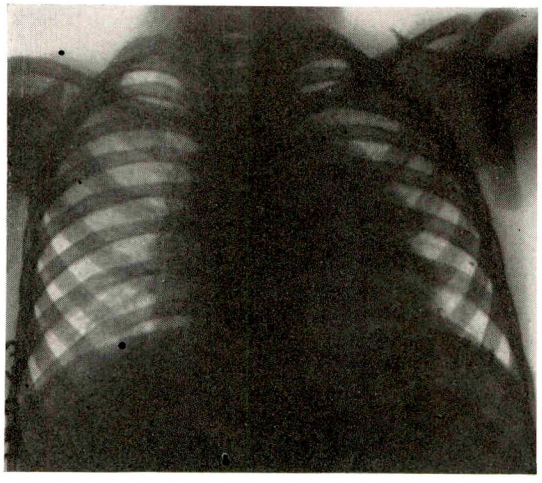


FIG. 9. Case III. Admission roentgenogram (November 15, 1939) reveals apparent wide mediastinum and large heart. Taken in supine position.

well nourished three year old colored male. There was slight enlargement of the cervical and inguinal nodes. The Mantoux reaction was positive. There was slight beading of the ribs and flaring of the ribs and wrists. The heart and lungs were negative. The abdomen was negative. The tonsils were hypertrophied and cryptic.

Laboratory Data. Blood count, blood chemistry, Wassermann reaction and urinalysis were normal. Gastric findings and feces negative for tubercle bacilli, erythrocyte sedimentation rate was 6 mm. per hour, temperature 100.5° F., weight 32 lb. The admission roentgenogram (Fig. 9) was interpreted as showing marked widening of the mediastinal shadow, due to tuberculous adenopathy.

The patient's course was uneventful. He remained afebrile, gastric findings were always negative for tubercle bacilli, and he might have been discharged except for roentgen findings of widened mediastinum. An upright roentgenogram on March 30, 1941 (Fig. 11) showed mediastinum of normal width and patient was discharged. A horizontal roentgenogram (Fig. 10) made at the same time again revealed apparent widening of the mediastinal shadow.

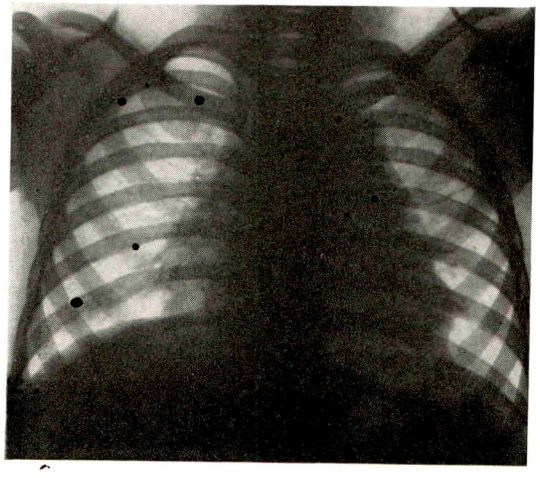


FIG. 10. Case III. Supine roentgenogram taken sixteen months later (March 30, 1941) shows persistence of wide mediastinal shadow. On basis of this roentgenogram patient would not have been discharged.

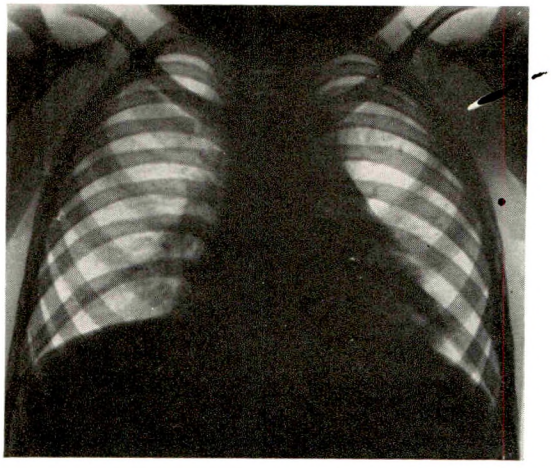


FIG. 11. Case III. Posteroanterior upright roentgenogram made at same time as Figure 10 reveals normal mediastinum and no enlarged nodes. Patient discharged as result of this roentgenogram.

Comment. The admission roentgenogram would probably have shown a normal mediastinum if it had been taken in the upright position. Two years later (Fig. 10) the roentgenogram taken in the supine position still shows apparent marked widening of the mediastinum and enlargement of the cardiac silhouette, though this disappears in the upright roentgenogram (Fig. 11). The lack of calcification in the hilar or paratracheal nodes on his final roentgenograms (four years after original hospitalization) throws doubt on whether caseous enlarged hilar nodes were originally present.

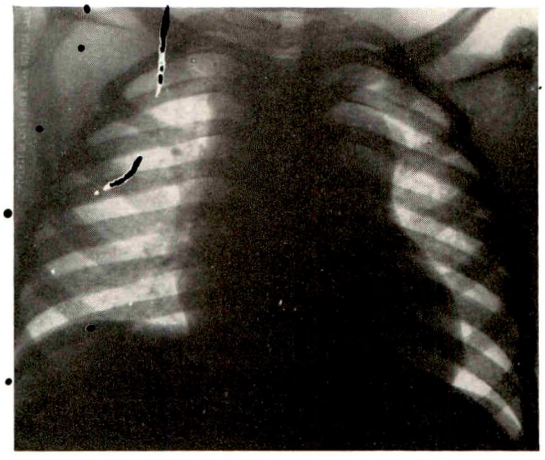


Fig. 12. Case IV. Anteroposterior expiratory horizontal roentgenogram (April 25, 1941) reveals widest mediastinal and heart shadow and poorest aeration of lungs.

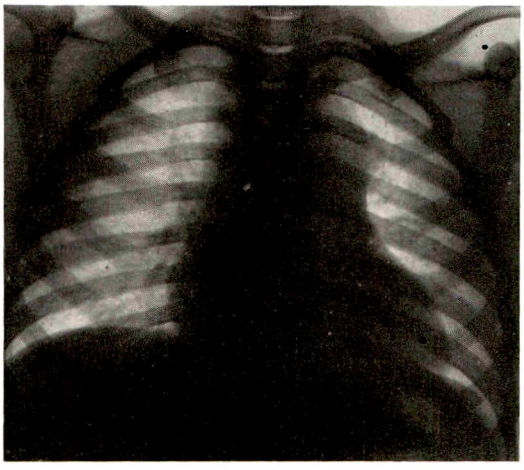


Fig. 14. Case IV. Anteroposterior expiratory upright film, taken at same time shows heart and mediastinal shadows to be much narrower than Figures 12 and 13.

Case IV (Fig. 12, 13, 14 and 15). C. W., colored male, admitted on October 29, 1940, at the age of eleven years because of loss of weight, low grade fever and roentgen findings of widened mediastinum and positive tuberculin test. The contact was found to be a boarder. Father, mother and brother all were found to be well. Past history revealed pertussis at nine months, varicella at three months, mumps at two years, pneumonia at one year and tonsillectomy at age of three years. Examination on admission revealed heart negative, lungs showing dullness in both apices posteriorly and diminished breath sounds in upper half of right chest posteriorly. The remainder of physical examination was negative. Laboratory findings included blood count, urinalysis, Wassermann test, blood chemistry—all normal. Feces and gastric findings negative for tubercle bacilli. Erythrocyte sedimentation rate 31 mm. per hour, temperature below 100° F., and roentgenogram of chest showed marked hilar adenopathy. During stay

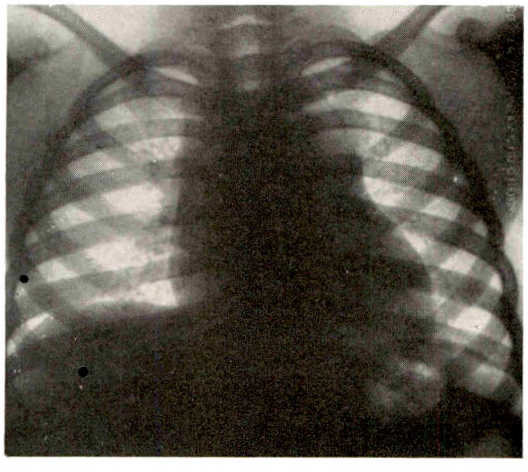


Fig. 13. Case IV. Posteroanterior expiratory horizontal roentgenogram, taken at the same time as Figure 12. Mediastinal and heart shadows are slightly narrower, but still strikingly enlarged and misleading.

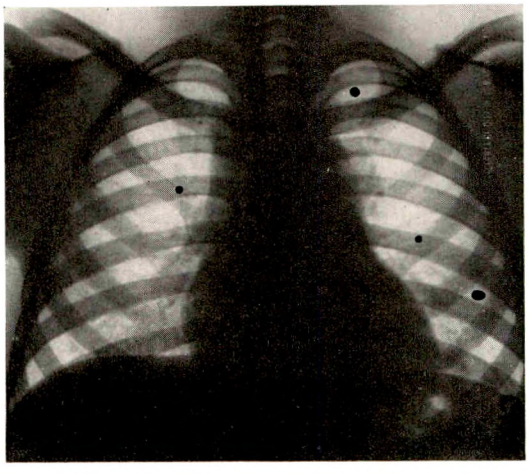


Fig. 15. Case IV. Posteroanterior expiratory upright roentgenogram (April 25, 1941) shows narrowest and most normal appearance of heart and mediastinum. Slight enlargement of the paratracheal nodes is still evident bilaterally.

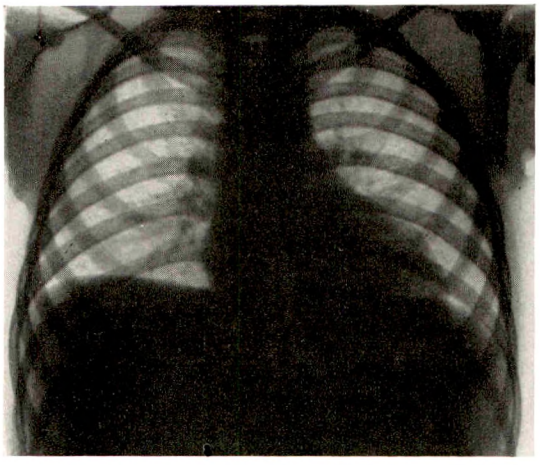


FIG. 16. Case v. Admission roentgenogram (January 30, 1940) was made in the upright position because patient was older and cooperative. Mediastinal shadow is narrow and normal, but heart shows wide transverse diameter because diaphragms are high (expiration) and push heart up.

in hospital, the temperature did not rise above 100° F., and patient was clinically negative. The erythrocyte sedimentation rate fell to 6 mm. per hour on January 29, 1941. Patient was discharged in April, 1941.

Comment. Just before discharge, four roentgenograms were taken in different positions (Fig. 12, 13, 14 and 15) which illustrate striking changes that may be produced due to roentgenographic technique. In Figure 15, though the mediastinal width is almost half that of Figure 12, it is still evident that slight enlargement of the paratracheal nodes is present. The upright technique will often reveal enlarged hilar or paratracheal nodes which in the supine position are obscured by false widening of the mediastinal shadow.

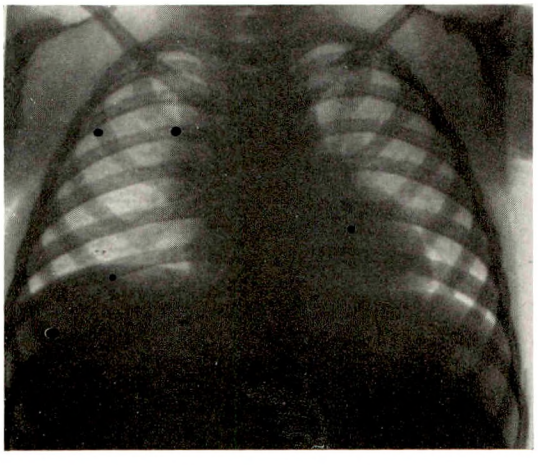


FIG. 17. Case v. Expiratory supine roentgenogram (October 15, 1940) shows apparent widening of the mediastinal shadow and marked enlargement of right paratracheal and bronchopulmonary nodes. Actually shadow is caused by elevation of diaphragms due to expiration, horizontal position plus slight rotation.

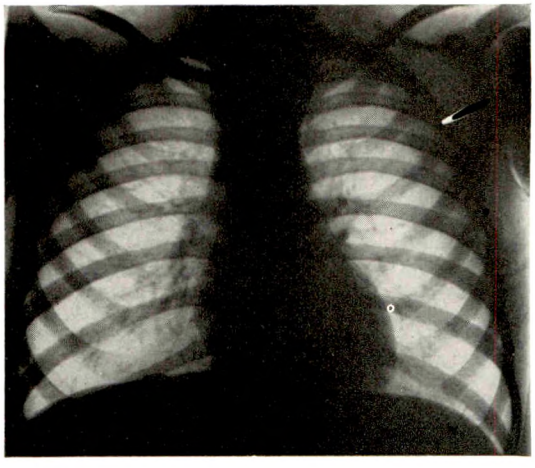


FIG. 18. Case v. Roentgenogram taken less than two months later (January 10, 1941) in posteroanterior upright inspiratory position, shows striking reversion of mediastinum and heart shadow to normal. Note greatly improved aeration of lungs.

CASE V (Fig. 16, 17 and 18). D. P., colored female, aged four, admitted to Sea View Hospital on January 29, 1940. The past history is irrelevant. The contact is not known. The patient was originally admitted to Harlem Hospital in December, 1939, for unexplained elevation of temperature, and while on the ward, she developed a large mass in the right axilla which was aspirated and found to contain tubercle bacilli. The child was then transferred to Sea View Hospital where physical examination on admission was essentially negative, except for enlargement of the cervical nodes to a little more than twice their normal size, and a mass half the size of a lemon in the right axilla. The blood chemistry, blood count and Wassermann test were normal. Hemoglobin was 66 per cent. Urine, feces and gastric examinations were negative for tubercle bacilli. The erythrocyte

sedimentation rate was 20 mm. per hour. The patch test was positive.

Admission roentgenogram of the chest (Fig. 16) revealed slightly increased prominence of the right hilar shadow and destruction of the posterior axillary segment of the ninth right rib. The patient's course was uneventful. The mass was aspirated once and then promptly healed. The patient was afebrile, except for an occasional rise to 100° F. The erythrocyte sedimentation rate returned to normal and the patient's condition continued to be satisfactory until October, 1940, when a chest roentgenogram (Fig. 17), taken in the horizontal position, showed marked increase in the width of the superior mediastinal shadow. The physical examination, sedimentation rate and temperature were all normal at this time. Another roentgenogram of the chest taken in the upright position (Fig. 18) again revealed a normal mediastinum and the patient was discharged from the hospital.

Comment. This patient was not admitted for either pulmonary or mediastinal tuberculosis and never had any clinical evidence of such. Yet Figure 17 might well be interpreted as showing enlarged bronchopulmonary and paratracheal nodes on the right. This case is especially interesting since Figure 16 (the admission roentgenogram) was an upright roentgenogram and shows a normal mediastinum, whereas Figure 17 was made in the horizontal position with striking alteration of the heart and mediastinal appearance. Figure 18, again made in the upright position, reveals a very normal heart and mediastinum. Also note how much better and more normal the appearance of the lungs are in the inspiratory upright roentgenogram (Fig. 18) than in the expiratory horizontal roentgenogram (Fig. 17).

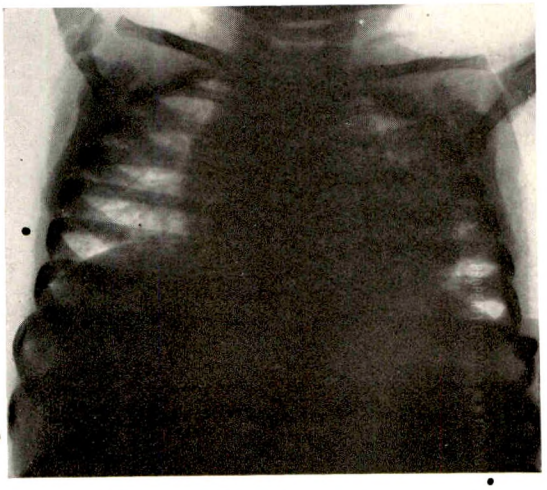


Fig. 19. Case VI. Roentgenogram taken in the posteroanterior horizontal position during forced expiration (child crying).

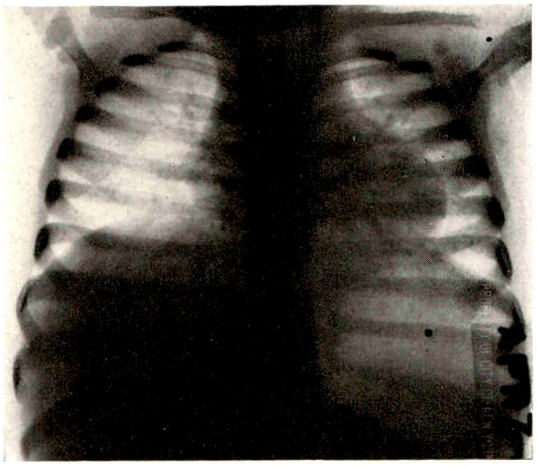


Fig. 20. Case VI. Roentgenogram taken five minutes after Figure 19, in the identical position but during inspiration.

Case VI (Fig. 19 and 20). P. D., aged three months, was admitted solely because mother was admitted as a patient with pulmonary tuberculosis. The infant was kept at the hospital for only three months until suitable home conditions could be arranged. At no time was there any evidence of tuberculosis. The patch test and Mantoux reaction were negative and roentgenogram of the chest normal. The gastric findings were negative for tubercle bacilli. On admission, patient was markedly dehydrated and underweight but responded promptly to routine care.

Comment. Figure 19 was taken at expiration in the horizontal posteroanterior position while the child was crying. This illustrates the marked changes in the aeration of the lungs and width of the mediastinal shadow and shape of the heart, as a result of increased intrathoracic pressure (crying). An erroneous diagnosis of enlarged thymus might be made from this roentgenogram.

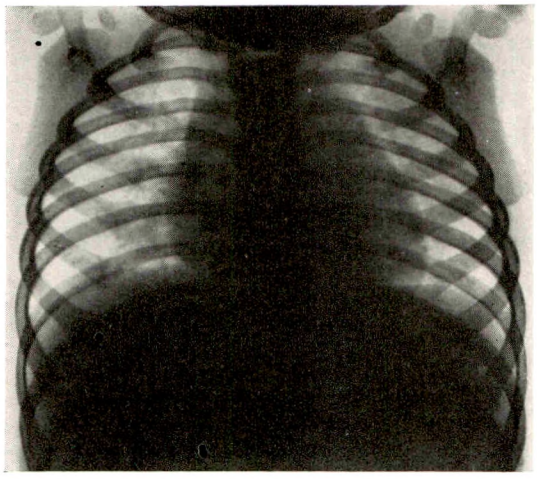


FIG. 21. Case VII. Anteroposterior expiratory roentgenogram in horizontal position.

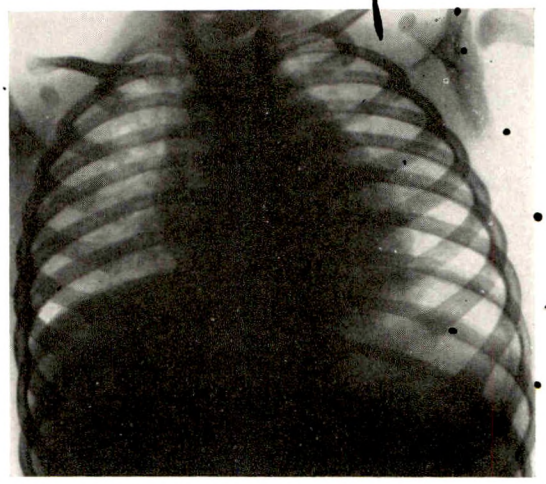


FIG. 23. Case VII. Posteroanterior expiratory roentgenogram in horizontal position.

FIG. 21–28. Case VII. These roentgenograms were all taken at the same time and illustrate the changes in the mediastinal and heart shadows due to variations in position and phase of respiration.

Figure 20 was made in exactly the same posteroanterior horizontal position but was taken during inspiration. The lung fields are much better aerated and the mediastinal and heart shadows much more normal in appearance, thus illustrating the changes due to inspiration and expiration alone.

CASE VII (Fig. 21–28). H. B., a newborn normal infant, whose mother was a tuberculous patient at Sea View Hospital and who was delivered by cesarean section on June 14, 1940. The child was immediately removed from the mother and remained in the hospital for two months, during which time arrangements were made for its care, after which it was discharged. The infant weighed $7\frac{1}{2}$ lb. at birth and remained well during its two months' stay in the institution. The tuberculin test was normal though the mediastinal shadow was thought to be widened. The child was brought back to the hospital on March 19, 1941, for a follow-up examination. The tuberculin test was still negative and a series of eight roentgenograms were taken in various positions and phases of respiration as part of this study.

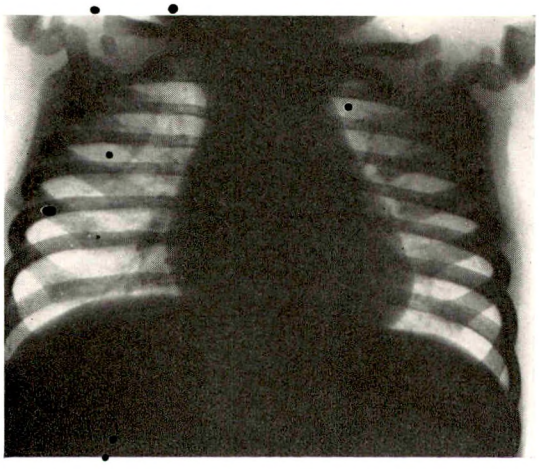


FIG. 22. Case VII. Anteroposterior inspiratory roentgenogram in horizontal position.

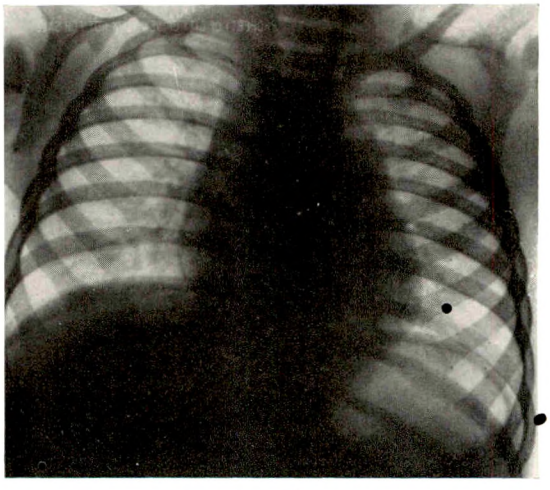


FIG. 24. Case VII. Posteroanterior inspiratory roentgenogram in horizontal position.

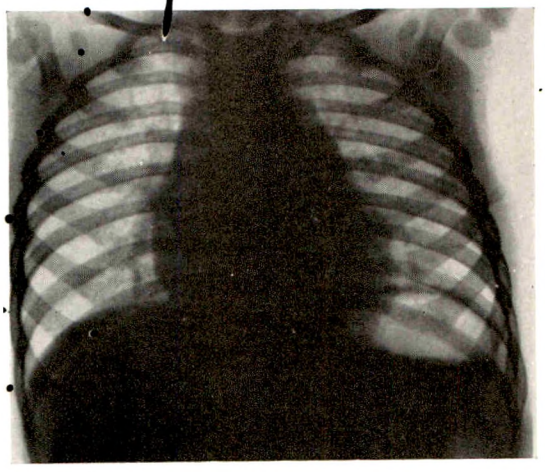


FIG. 25. Case VII. Anteroposterior expiratory roentgenogram in upright position.

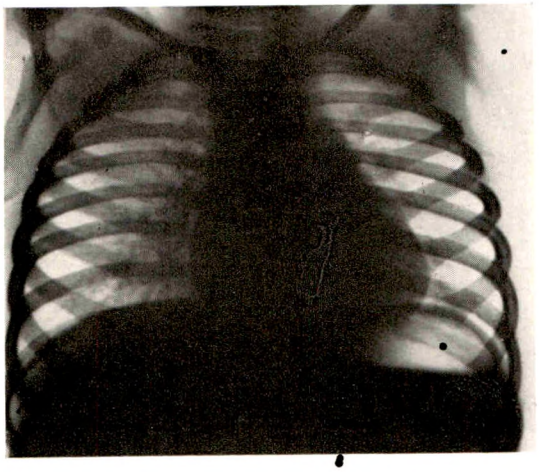


FIG. 27. Case VII. Posteroanterior expiratory roentgenogram in upright position.

Comment. This case illustrates the striking changes that may be produced by variations in roentgenographic technique. All eight roentgenograms were taken within half an hour. Figure 28 shows normal heart and mediastinum. Compare this with Figure 21 in which the heart shadow is enlarged and the mediastinum greatly widened. Figure 23, which was taken at expiration in the prone position, reveals congestion and marked diminution in aeration of the right lower lobe. A faulty diagnosis of bronchopneumonia in the right lower lobe might have been made on the basis of this roentgenogram. This can be appreciated more in the original roentgenogram than in the smaller reproduction here. The changing size and configuration of the heart shadow on all eight roentgenograms illustrates the errors inherent in measuring and judging heart size and shape, unless all roentgenograms being compared are made under identical conditions, i.e., same phase of cardiac cycle, same phase of respiration, same upright or horizontal anteroposterior or posteroanterior position.

This case also illustrates the fact that upright roentgenography of the chest is

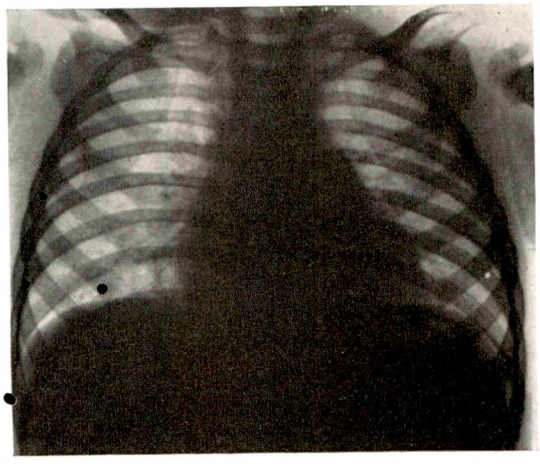


FIG. 26. Case VII. Anteroposterior inspiratory roentgenogram in upright position.

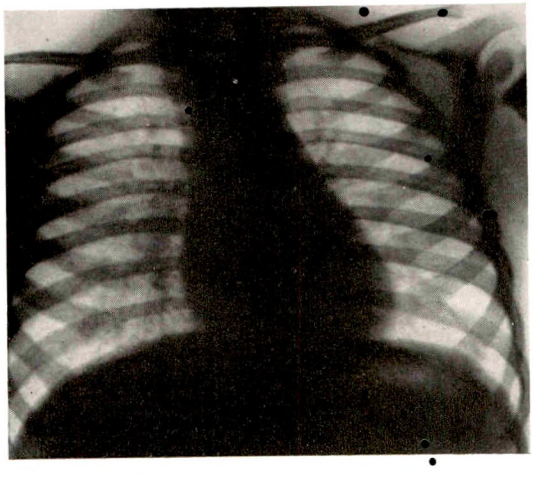


FIG. 28. Case VII. Posteroanterior inspiratory roentgenogram in upright position.

perfectly feasible even in the newborn. It is apparent that the mediastinal shadow is narrower and more normal in the roentgenograms taken in the posteroanterior position than those made in the antero-

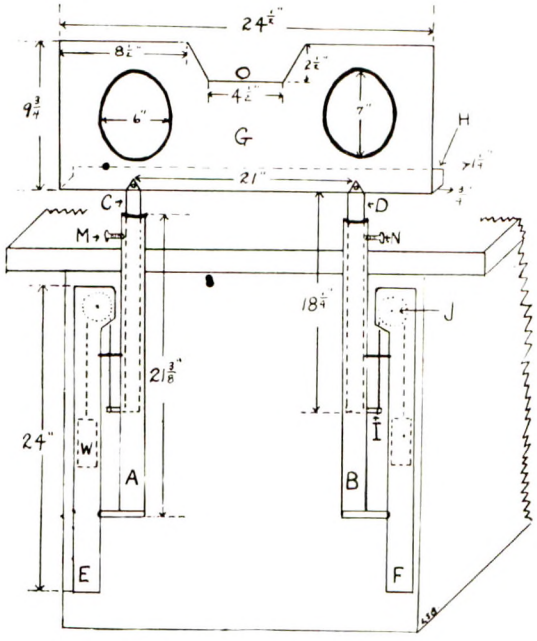


FIG. 29. Line drawing of apparatus.

posterior position; narrower and more normal in the upright than in the horizontal position; narrower and more normal on

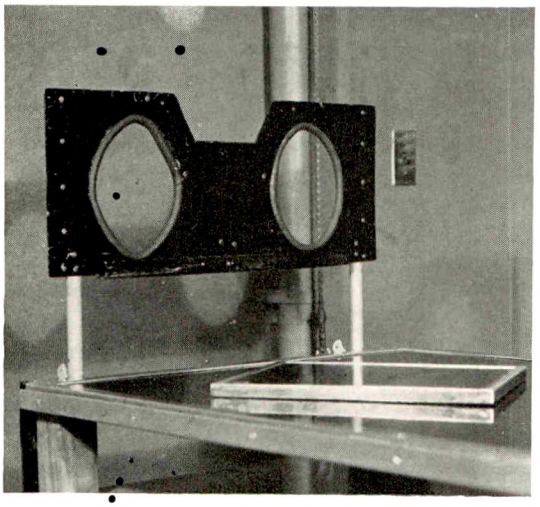


FIG. 30. Photograph of apparatus for upright roentgenography of the chest.

roentgenograms taken in inspiration than on those made in expiration.

DESCRIPTION OF APPARATUS

The apparatus used to facilitate upright roentgenography is illustrated in Figure 29. It consists of a metal plate (*G*) 24½ in. wide by 9¾ in. high, in which there are two large oval apertures, each 6 by 7 in. in diameter, one on each side to accommodate the arms of the patient, which project through the armholes and are held by the nurse or attendant (see Fig. 31). The holes are lined by sponge rubber to avoid scratching the patient. The lower edge of the metal plate is bent so as to form a right angle shallow trough (*H*) upon which the cassette rests. The metal plate *G* is thus converted into a simple and inexpensive cassette holder. To the lower edge of the cassette holder, near

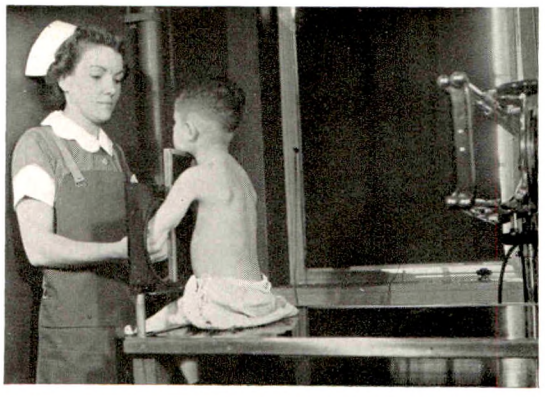


FIG. 31. Photograph of apparatus showing patient, cassette and attendant in position for upright chest roentgenography.

either end, are riveted two round bars of ½ in. brass pipe (*C* and *D*) which, in turn, telescope within two brass pipes of ¾ in. diameter (*A* and *B*). To the lower ends of pipes *C* and *D* there is welded at right angles a small metal rod (*I*) to which is attached a light wire cable which passes around pulley (*J*) and is attached to counterweight (*W*). The counterweight moves within a brass pipe (*E*), attached to the end of the roentgenographic table and which is secured to pipes *A* and *B* by means of weld (*K*). Pipes *A* and *B* are also secured

rigidly to each edge of the end of the roentgenographic table and each pipe has a narrow slit running along its entire length to allow rod *I* to move up and down. At the upper end of pipes *A* and *B*, there is a threaded hole to accommodate thumb screws (*M* and *N*) which, when turned, lock the cassette holder at the desired height. The tray of the cassette holder *G* has a cut-out (*O*) to accommodate the chin. When the apparatus is not in use, the thumb screws are loosened and the entire cassette holder and attached bars *A* and *B* can be very easily lifted out and removed from the apparatus. This is a very necessary and desirable feature, since it leaves the end of the roentgenographic table free and unobstructed.

The entire apparatus is secured rigidly to one end of the roentgenographic table and requires only a touch of the finger to move up or down because of the counterweight and pulley arrangement. The patient sits on the edge of the table (see Fig. 31), and arms are passed through the armholes and held by the nurse. This bring the chest of the patient against the cassette and the roentgen tube is simply turned to focus the central ray toward the patient. In this way, posteroanterior upright roentgenograms can be secured with equal facility at 6 ft. distance as at 30 in., which is a great advantage when studying the heart size and shape in children. Even newborn infants have been roentgenographed with this apparatus with less difficulty than in the conventional horizontal position and the resulting roentgenograms have been superior in all respects. Lateral and oblique views can be secured as readily as posteroanterior views by simply turning the sitting child to the desired angle. Teleroentgenograms for heart study are secured with great ease by simply moving the rail mounted tubestand back to 6 ft. distance.

The device has been found of great value in roentgenography of adults as well as infants since it happens not infrequently that a sick adult is able to sit up with support but is unable to stand. Thus, by using this apparatus, excellent 6 ft. roentgenograms can be secured in place of the generally unsatisfactory 36 in. distance horizontal films. This is particularly advantageous in roentgenography of decompensated cardiac patients. The apparatus is very substantial, is extremely simple in operation, very inexpensive, can be easily home made, and is suitable for attachment to any table.

It must be emphasized that the nurse or attendant who holds the arms of the patient is thereby exposed to the rays and should always wear a lead apron when the exposure is made.

SUMMARY

The difference in results with upright and horizontal chest roentgenography has been compared and analyzed in 25 cases. Ten of these cases were selected for special study to determine the effects of respiratory phase, position (upright or horizontal) and type of projection (anteroposterior or posteroanterior). An explanation is offered for the striking variations that may result from changes in the method of roentgenographic examination, and the importance of the upright position is emphasized. The anatomy of the mediastinum is briefly reviewed.

CONCLUSIONS

1. The horizontal method of chest roentgenography should be replaced by, or augmented by, the upright method. No reliance should be placed on the horizontal method alone.
2. Upright posteroanterior roentgenograms taken at the end of inspiration give the least distorted views of the mediastinum.
3. Cardiac measurements are not completely reliable and comparable by serial study unless the exposures are synchronized with a phase of the cardiac cycle.
4. The diagnosis of "enlarged thymus" is too often erroneous because of mediastinal widening due to technical

factors. Roentgenography of the thymus should include upright posteroanterior and lateral views.

5. Upright posteroanterior views taken at the end of inspiration are most satisfactory.
6. A simple, inexpensive device can be made to provide such views.
7. Bronchopneumonia may, on occasion, be incorrectly read into roentgenograms made in the horizontal position, at the end of expiration. Roentgenograms so taken should be interpreted with caution.

REFERENCES

1. ALEXANDER, W. G. X-ray in children. *Wisconsin M. J.*, 1927, *26*, 441–449.
2. BENJAMIN, E., and GOETT, T. Interpretation of chest roentgenogram in the nursling. *Deutsches Arch. f. klin. Med.*, 1912, *107*, 508–517.
3. BIGLER, J. A. Interpretation of roentgenograms of chest in children based on observations at necropsy. III. Disease of the lungs, of the pleura and of the mediastinum. *Am. J. Dis. Child.*, 1930, *39*, 91–106.
4. BLACKFAN, K. D., and LITTLE, K. Clinical and radiographic study of thymus in infants. *Am. J. Dis. Child.*, 1921, *22*, 459–470.
5. BONAR, B. E. Thymus in childhood. *Northwest Med.*, 1928, *27*, 178–182.
6. CUNNINGHAM, D. J. Textbook of Anatomy. Edited by J. C. Brash and E. B. Jamieson. Sixth edition. Oxford University Press, New York, 1931, pp. 916–917.
7. DANN, D. S. The uncoiled aorta. Part I. The normal aorta. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *23*, 358–372.
8. ENGEL, S., and SCHALL, L. Handbuch der Röntgen-Diagnostik und -therapie im Kindesalter. Georg Thieme, Leipzig, 1933.
9. FARRELL, J. T., JR. Roentgen appearance of the chest of the new-born infant. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 140–146.
10. GERSTENBERGER, H. J. Factor of position of diaphragm in roentgen ray diagnosis of enlarged thymus. *Am. J. Dis. Child.*, 1921, *21*, 534–545.
11. GROEDEL, F. M., and DIETLEN, H. Quoted by Gerstenberger.[10]
12. HOLZKNECHT and HOFBAUER. Quoted by Benjamin and Goett.[2]
13. KING, J. C. Thymic enlargement in children. *Radiology*, 1927, *9*, 148–152.
14. KLEINSCHMIDT, H. Zur Röntgendiagnostik der Thymushyperplasie. *Monatschr. f. Kinderh.*, 1927, *37*, 358–364.
15. KOHN, J. L., and KOIRANSKY, H. Immobilizing apparatus for taking chest roentgenograms in young children. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *25*, 100–102.
16. KRAUSE, A. K. Spread of tuberculous infection in the body. *Am. Rev. Tuberc.*, 1924, *9*, 83.
17. MANGES, W. F. Roentgen-ray diagnosis of non-opaque foreign bodies in air passages. AM. J. ROENTGENOL., 1922, *9*, 288–303.
18. MARGOLIES, A. X-ray of heart and great vessels. Cyclopedia of Medicine. Edited by C. E. Sajous and G. M. Piersol. F. A. Davis Co., Philadelphia, 1932, Vol. III, p. 424.
19. MCPHEDRAN, F. M. X-ray diagnosis of pulmonary tuberculosis. *Am. Rev. Tuberc.*, 1927, *16*, 420–436.
20. MCPHEDRAN, F. M., and WEYL, C. N. Clinical and physiologic deductions from synchronized roentgen-ray exposures. *Am. J. M. Sc.*, 1927, *173*, 313–322.
21. MORSE, J. L. Thymus obsession. *Boston M. & S. J.*, 1928, *197*, 1547–1552.
22. PANCOAST, H. K. Roentgenology of thymus in infancy and differential diagnoses of enlarged thymus with its treatment. *Am. J. M. Sc.*, 1930, *180*, 745–767.
23. PANCOAST, H. K., and PENDERGRASS, E. P. Roentgenologic diagnosis of diseases of upper respiratory tract in children. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *23*, 241–264.
24. PODLASKY, H. B., and KOHN, S. E. Thymic shadows of new-born infants. *Am. J. Dis. Child.*, 1930, *39*, 782–789.
25. REMER, J., and BELDEN, W. W. Roentgen diagnosis and treatment of thymus in children. AM. J. ROENTGENOL. & RAD. THERAPY, 1927. *18*, 119–124.
26. WASSON, W. W. Thymic stridor. *J. Am. M. Ass.*, 1927, *89*, 1025–1028.
27. WEYMULLER, C. A., BELL, A. L. L., and KRAHULIK, L. Roentgenographic changes in thorax of normal new-born babies. *Am. J. Dis. Child.*, 1928, *35*, 837–855.
28. WOOD, H. C., JR. Frame for holding infants upright during roentgenography. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 396–398.

VOL. 49, NO. 2

OIL ASPIRATION PNEUMONIA

By MORRIS MOEL, M.D., B.S.
*Formerly, Resident in Roentgenology, Welfare Hospital**
and
HENRY K. TAYLOR, M.D., F.A.C.P., F.A.C.R.
Roentgenologist, Welfare Hospital
NEW YORK, NEW YORK

SINCE Laughlen's[8] report of 5 cases of oil aspiration pneumonia, numerous authors have reported either isolated cases or small groups of cases, and, in a few instances, larger series. Most of the cases described were discovered at postmortem examination. Pinkerton[10] found 6 cases in 290 necropsies of infants and children. Bromer and Wolman[1] reported 27 cases in children. Of these, 8 were diagnosed clinically, and 1 of these, as well as the other 19, was confirmed as oil aspiration pneumonia on postmortem study. Goodwin[6] found 25 cases in children during a ten year period at the Harriet Lane House. Of these, only 3 were diagnosed clinically. Cannon[3] found 39 cases in 2,000 consecutive necropsies, of which 12 were in infants and children, and 27 in adults. Freiman, Engelberg and Merrit[5] reported a series of 47 cases of oil aspiration pneumonia. Of these, 7 were diagnosed clinically, and 40 were found in 3,500 consecutive autopsies over a period of ten years.

The number of cases of oil aspiration pneumonia in the literature is not very large. Undoubtedly many cases have been recognized but not reported. It is our belief that the incidence of this disease is much greater than one would estimate from the number of cases reported in the literature. Because of this, we wish to report our experiences.

ETIOLOGY AND PATHOLOGY

The etiology and pathology of oil aspiration pneumonia have been well established and described by Pinkerton,[11] Cannon,[2] Cannon and Walsh,[4] Laughlen[8] and Ikeda.[7] The causative agent is a lipoid, or lipid substance, entering the lungs in one of three ways: (1) through the mouth; (2) instilled into the nose as drops; (3) through a tracheotomy opening.

Responsible lipoids may be divided into three groups:

1. *Animal oils:* halibut liver and cod liver oils, milk and egg yolk.
2. *Vegetable oils:* castor oil, olive oil and wheat germ oil.
3. *Mineral oils:* liquid petrolatum.

The predisposing conditions favoring the development of oil aspiration pneumonia are chiefly those which interfere with the normal swallowing act. They are:

1. Perforated palate.
2. Forceful feeding in crying and debilitated children.
3. Neurologic conditions at any age causing dysphagia, such as multiple sclerosis, cerebrovascular disease, brain tumors, etc.
4. All debilitating diseases compelling the patients to become bedridden, such as the arthritides, Little's disease, neurological conditions, etc. Aside from the fact that these patients have difficulty in swallowing, they become constipated. To alleviate the constipation, mineral oil is administered.
5. Upper respiratory infections—treated by intranasal administration of oily medications.

The pathogenesis and pathologic pictures have been established and described by Cannon. The fundamental pulmonary lesion is essentially a low grade interstitial proliferative type of inflammation with a foreign body reaction. The lesion has been described as showing numerous endotheliocytes in the involved lung area or areas with giant cell formation of the foreign body

* Resident, July 1, 1940, to June 30, 1941.

type. The lipoid substance is both intra- and extracellular, the latter being in the alveolar spaces. The epithelial lining of the alveolar spaces assumes a cuboidal form. The mononuclear endotheliocytes contain oil droplets. Many of the cells have a signet ring appearance with the oil occupying the cytoplasmic portions of the cells. The nucleus is eccentrically placed. There is some round cell infiltration. A superimposed bronchopneumonia may accompany the oil aspiration pneumonia. The lymphatics become permeated with oil-laden cells. Some of the oil may be carried to the hilar lymph nodes. Cases have been reported by Pinkerton and Moragues[12] and Young, Applebaum and Wasserman,[14] where the oil has been found in distant organs such as the liver and spleen. The more frequent locations of oil aspiration are in the lower lobes, most commonly in the right lower lobe. Any or all lobes may be involved.

The severity of the reaction depends upon the type of oil used. The difference in degree of toxicity of the various types of oils has been shown by Ikeda, and Pinkerton and Cannon, and their findings are generally in agreement.

Vegetable oils, as a group, are least irritating, least toxic, producing a slight degree of proliferative reaction with invasion of macrophages. The pure vegetables oils, such as olive oil, cotton seed oil and oil of sesame die free in the alveoli, produce no symptoms, and may be largely removed by coughing and expectoration. Chaulmoogra, a vegetable oil, has been found to be very damaging because of its high fatty acid content.

Animal oils, as a group, are the most toxic. This is due to their high fatty acid value and the ease with which they undergo hydrolysis. The more unsaturated the oil, the easier it hydrolizes, the greater the reaction (Paterson)[9]. For this reason the most toxic of the animal oils is cod liver oil.

Unlike animal and vegetable oils, liquid petrolatum is chemically inert and acts purely as a foreign body in the pulmonary parenchyma. It is eliminated partly by expectoration and partly removed through the lymphatics by wandering cells. According to Ikeda, the presence of mineral oil in the lung causes local irritation which results in a low grade proliferative inflammation analogous to a foreign body reaction. Medicinal agents such as menthol, thymol and ephedrine are responsible for an acute diffuse exudative inflammation because of the chemical irritation to the lungs. The result is a superimposed acute inflammation on a foreign body reaction. The former often subsides spontaneously in the absence of bacterial invasion, while the petroleum continues to act as a foreign body.

Wolman and Bayard[13] described a characteristic fluorescence to the consolidations of oil aspiration pneumonia in human lungs when examined in a dark room under ultraviolet light. The areas of consolidation were visible as pale yellow, gray, white or greenish fluorescence. They claim that the various lipoid substances have a specific fluorescent color and that the pathologic diagnosis should state specifically the causative agent by diagnosing the lesion as either mineral oil pneumonia, cod liver oil pneumonia, milk aspiration pneumonia, etc., instead of the general term oil aspiration pneumonia. In their experimental work they were unable to demonstrate lipid deposits and signs of chronicity when milk was the causative agent. They recommend that milk aspiration pneumonia be separated from the term oil aspiration pneumonia.

The lesions of oil aspiration pneumonia have been classified by various authors. Cannon and Walsh described the lesion as an exudative or proliferative inflammation, depending upon the amount and kind of lipoid agent used. The lesion may be diffuse or local. The acute state is exudative. It is caused by the accumulation of lipophages in the alveoli, often with secondary infection. The later stage is characterized by interstitial fibrosis.

Pinkerton divided the oil aspiration pneumonia due to liquid petrolatum into two types very similar to the division used

by Cannon (1) acute pneumonic process characterized by the accumulation of macrophages and round cells; (2) the second type is characterized by marked fibrosis with multiple nodules in the lungs. These nodules are composed of large globules of liquid petrolatum imbedded in dense fibrous tissue and are comparable to the so-called paraffinomas.

Ikeda[7] similarly described two types, the infantile and adult. In the infantile type the etiologic agents are cod liver oil, milk and mineral oil. It is essentially an interstitial proliferative inflammation not infrequently combined with an exudative pneumonia. The exudative pneumonia is due either to the irritation of the oil or to bacterial invasion. The adult type is the result of the administration of oil in large amounts by either the nasal or oral routes over a prolonged period of time. Liquid petrolatum and its numerous medicated preparations are the responsible agents. He described the adult type as being essentially a paraffinoma in its various stages of development. These stages extend from early non-suppurative proliferative interstitial pneumonitis to a chronic granulomatous foreign body reaction with widespread fibrosis and tumefaction. The infantile type of oil aspiration pneumonia may be regarded as representing the initial stage of the adult type. The fundamental process is essentially that of a foreign body reaction to the presence of an insoluble oil and consists primarily of (1) the massive infiltration of macrophages; (2) the proliferation of stroma cells, and (3) the appearance of foreign body giant cells.

According to the pathologic findings as described by various authors, one may divide the lesions into three types:

(1) Diffuse acute—representing the first stage and corresponding to the infantile type of Ikeda.

(2) Diffuse chronic—representing the intermediate stage, and consisting essentially of a proliferative fibrosis. In this stage acute bronchopneumonia may be superimposed.

(3) Chronic localized—representing the tumor-like paraffinomas.

CLINICAL ASPECTS

The clinical signs and symptoms are indefinite and not at all characteristic. The most common symptom is cough, which may be either productive or non-productive. There may be shortness of breath. The temperature usually remains normal unless there is a superimposed bronchopneumonia. There may be a concomitant infection other than in the pulmonary system, such as infected decubitus ulcers, or infections in the urinary tracts. In these cases, a low grade temperature is present. Pain in the chest is rarely a complaint. The physical signs are even less constant. One may hear increased voice and breath sounds, dry and moist râles, particularly at the bases. The patient may be asymptomatic, and show definite roentgen findings.

The roentgen findings have been described by Bromer and Wolman.[1] They classify the lesions as mild, moderate and severe. This classification is not dependent upon a time factor following aspiration or upon the kind of oil used. In their series the extent of involvement depended upon the quantity of oil in the lung, regardless of whether it was aspirated in a single large dose or in repeated small doses. Patients having only a mild involvement showed an increase in the size and density of the lung markings and hilar shadows. Scattered small areas of increased density may be present about the hilar shadows. These findings are pronounced in the group with moderate involvement. In the severe cases the perihilar shadows spread out toward the periphery of the lungs, usually leaving a narrow clear zone adjacent to the axillary chest wall. A true lobar pneumonia is not observed unless a non-lipoid pneumonia is superimposed. A paraffinoma is recognized in the roentgenogram as a well defined localized area of absent aeration which may be difficult or impossible to differentiate from a pulmonary neoplasm.

With oil aspiration pneumonia there is

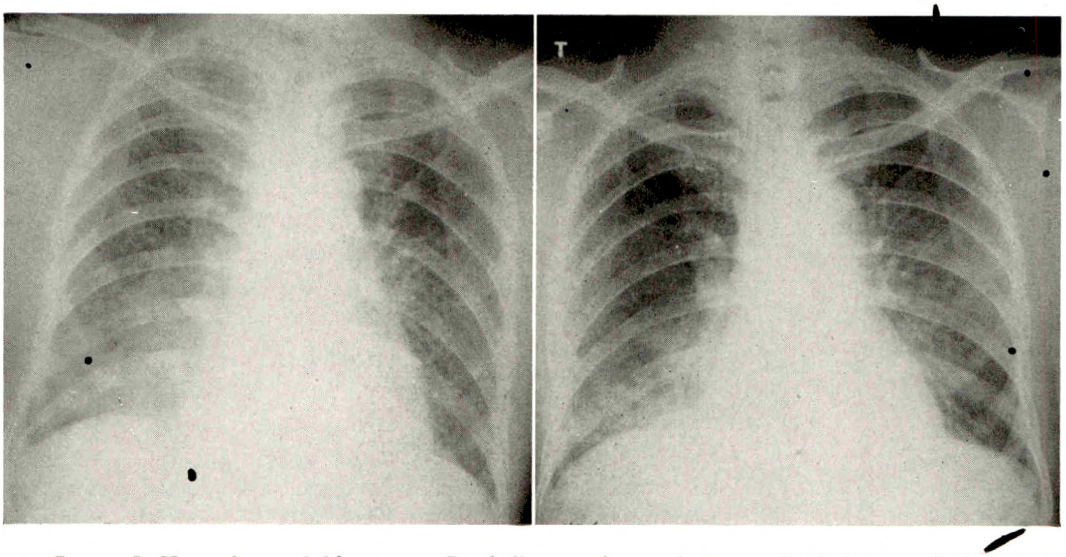


FIG. 1. Case I. G. K., male, aged fifty-seven. Cerebellar pontine angle tumor. Daily intake of mineral oil for more than one year, until one year ago. Persistent changes of coalescent bronchopneumonia in the right lower lobe for more than five months.

little or no change in the appearance of the lung fields on serial roentgenograms. This, together with the history of oil administration and difficulty in swallowing, should establish the diagnosis.

DISCUSSION OF CASES

Twenty cases of oil aspiration pneumonia were diagnosed clinically within a period of seven months at Welfare Hospital for Chronic Diseases.* Of these, 5 were sub-

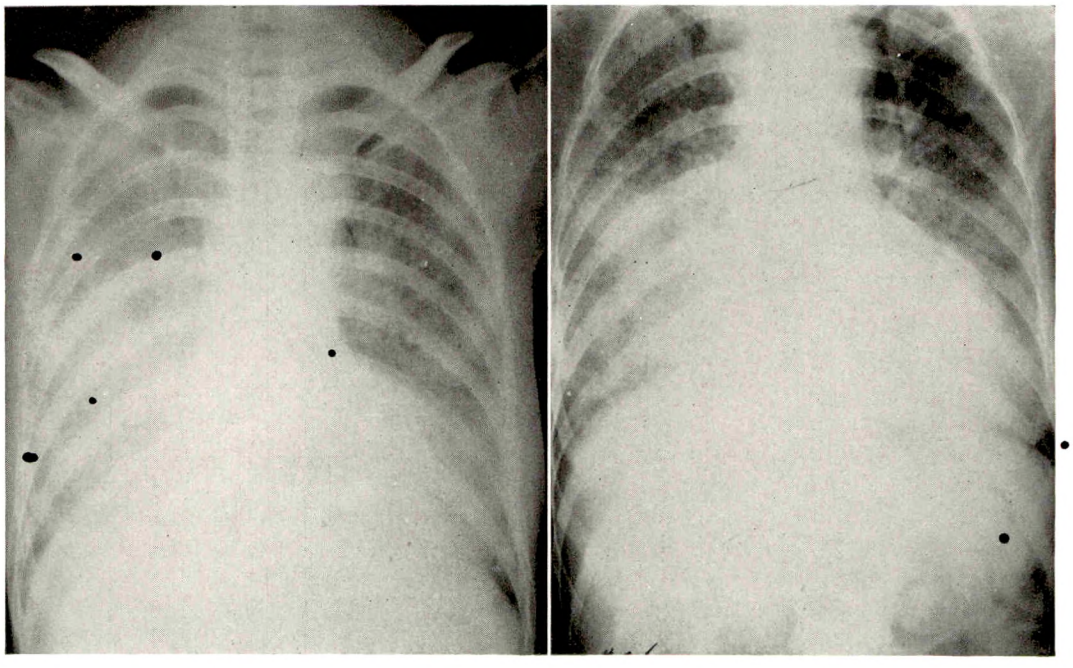


FIG. 2. Case II. M. W., female, aged fifty-one. Multiple cerebral vascular accidents with pseudobulbar palsy syndrome and aphasia. Debilitated for many years. Difficulty in swallowing. Received 25 ounces of mineral oil for three months prior to admission. Diffuse parenchymal changes persistent for more than three months. Postmortem confirmed findings of oil aspiration pneumonia.

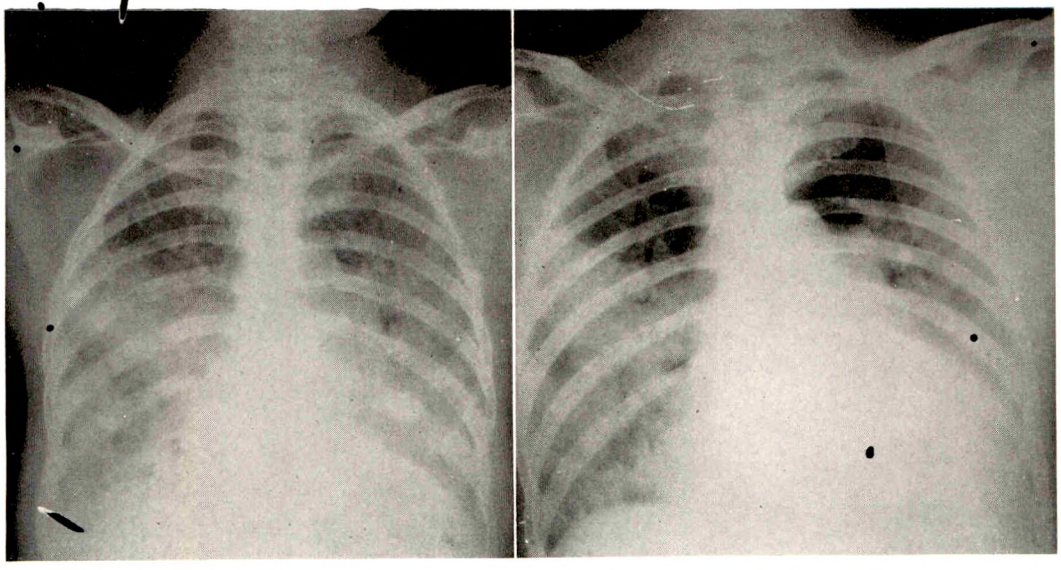


FIG. 3. Case III. I. C., female, aged forty-three. Hemiplegic for five years. Bedridden. Diffuse bilateral parenchymal changes for more than fourteen months. Postmortem confirmed findings of oil aspiration pneumonia.

sequently proved at necropsy. The apparent high incidence is attributed to the fact that most of our patients are aged and bedridden.

Because of the protracted character of a lesion in 2 cases diagnosed as bronchopneumonia, our investigation was started which ultimately led to the diagnosis of oil aspiration pneumonia. A review of our so-called protracted bronchopneumonias revealed several patients with oil aspiration pneumonia.

Our interest led us to investigate the

* Welfare Hospital was opened to patients in July, 1939.

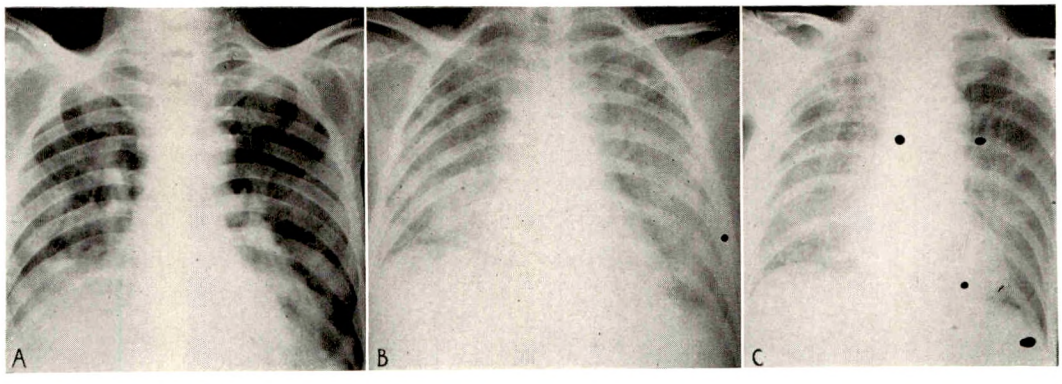


FIG. 4. Cases IV, V and VI.

A, Case IV. D. C., male, aged forty-six. Amyotrophic lateral sclerosis. Difficulty in swallowing. Bedridden for one year. Received 37 ounces of wheat germ oil, 2 ounces of castor oil during his hospital stay. Diffuse coalescent bronchopneumonia due to oil aspiration pneumonia. Postmortem confirmed findings of oil aspiration pneumonia and confluent lobular pneumonia.

B, Case V. L. Mc., female, aged forty-three. Multiple sclerosis. Dysphagic and bedridden for many years. Mineral oil intake for more than one year. Diffuse coalescent bronchopneumonia due to oil aspiration pneumonia.

C, Case VI. E. K., female, aged sixty-nine. Debilitated and bedridden. Dysphagic and regurgitated food. Daily intake of oil over a long period of time. Diffuse parenchymal changes due to oil aspiration pneumonia. Postmortem confirmed findings of oil aspiration pneumonia.

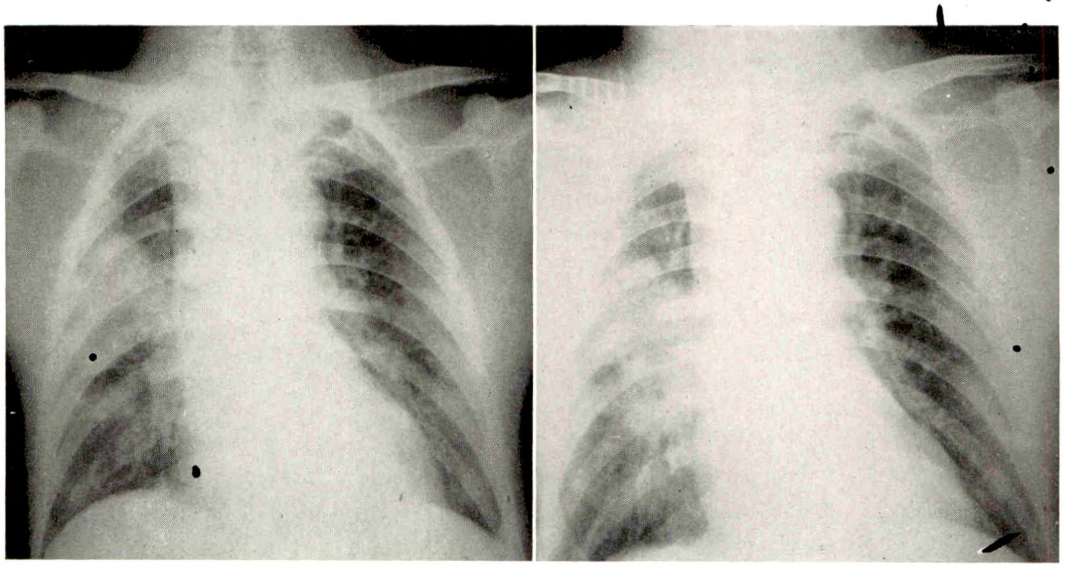


FIG. 5. Case VII. T. R., male, aged sixty-five. Rheumatoid arthritis. Bedridden several years. Difficulty in swallowing. Daily intake of mineral oil. Persistent lesion in the basal and axillary portion of the right upper lobe for more than nineteen months.

necropsy records, and we found 13 additional cases in 300 consecutive autopsies in a period of eighteen months. These are not included in this report. Some of these cases might have been diagnosed antemortem had we been thinking of oil aspiration pneumonia.

Among the 20 cases the sexes were equally divided. Their ages ranged from twenty-six to eighty-two years. In all these cases an accompanying disease contributing to the development of oil aspiration pneumonia was present. These patients could be divided into three groups: neuro-

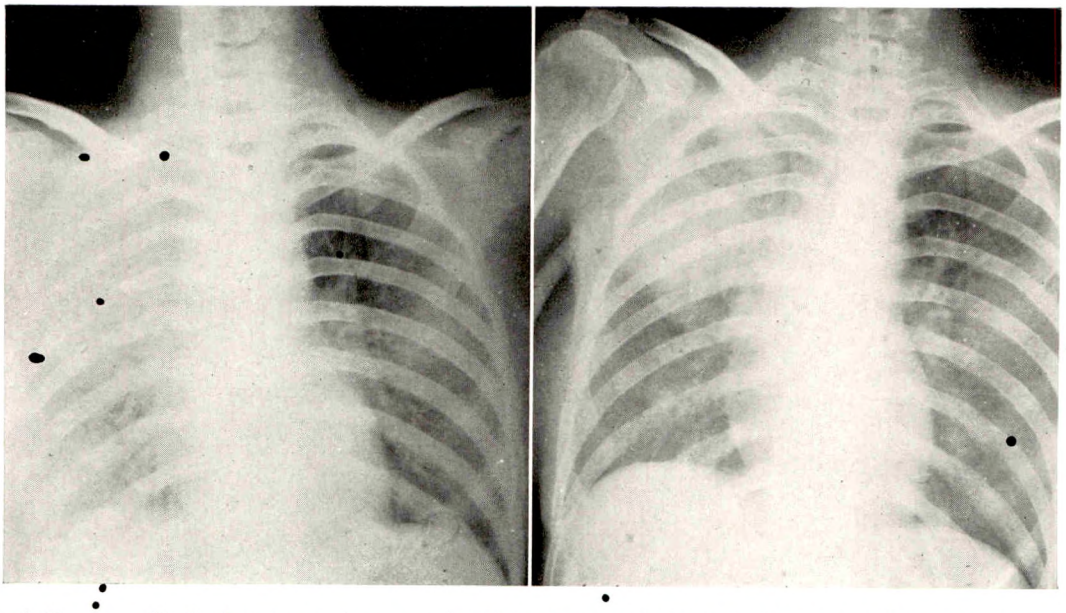


FIG. 6. Case VIII. E. G., female, aged twenty-six. Multiple sclerosis. Dysphagic and bedridden for more than one year; 5 cc. wheat germ oil daily for nineteen months. Persistent coalescent lesion in the right upper lobe for more than twenty-three months.

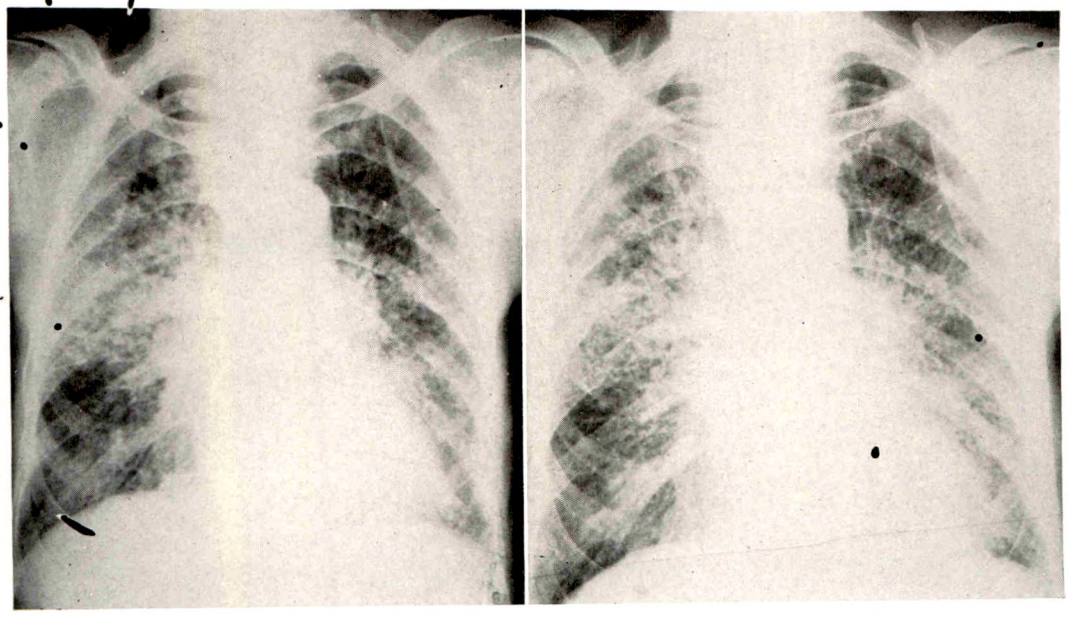


Fig. 7. Case IX. A. E., female, aged eighty-seven. Bedridden for the past seven months. Pulmonary roentgen findings have persisted for more than three months. No history of intake of oil. Clinical investigation leads to the diagnosis of aspiration of milk.

logical, cerebrovascular and arthritics. In the neurologic group there were 6 with multiple sclerosis, 1 spastic pseudosclerosis, 1 Little's disease, and 1 cerebellar syndrome with cerebellar pontine tumor (operated). There were 4 hemiplegics in the cerebrovascular group. In the third group were 7 patients with advanced chronic rheumatoid arthritis. One in this group also had an accompanying Parkinson's syndrome. The younger age group was in the neurological patients. Their ages ranged from twenty-six to fifty-one, with the exception of one aged fifty-seven, with the cerebellar pontine tumor. The rheumatoid arthritics and hemiplegics were of the older age group. The predisposing and contributing factors in the development of oil aspiration pneumonia were the accompanying dysphagia, weakness and debility.

The oil in all of our patients was administered orally. The most common causative agent was liquid petrolatum given for constipation. A positive history of having taken considerable quantities of mineral oil was obtained in 12 cases. The oil intake was usually an ounce, either daily or every second or third day, over a period of from two months to two years. Two cases, obtaining vitamin therapy, received wheat germ oil frequently for a period of one to two months.

In 6 cases, no history could be obtained of receiving any specific oils. In these cases we knew that no oil had been administered at Welfare Hospital. We could not ascertain whether the patients had received oil prior to their admission. Nevertheless, the roentgen examination of the chests revealed changes suggestive of oil aspiration pneumonia. One case was proved on autopsy. In this case no history of oil administration was obtained.

All our patients received considerable quantities of milk daily. This may have been a factor in the production of oil aspiration pneumonia in some of the cases.

It is our opinion that a diagnosis should be considered in dysphagic and debilitated patients; particularly when serial roentgenograms reveal evidences of a protracted bronchopneumonia, even when no history of oil ingestion is obtainable.

The incidence of oil aspiration pneu-

monia is recognized. Because of this, oily medications and the use of liquid petrolatum have been greatly reduced at Welfare Hospital.

In the diagnosis of oil aspiration pneumonia the clinical signs and symptoms may be of little or no value. In some of our cases no signs or symptoms were elicited, while in others a few moist râles at the bases, and dullness were present. A few patients disclosed a low grade fever. A higher temperature usually indicated a superimposed acute bronchopneumonia or some other infection.

The roentgen examinations revealed an increase in the size, number and density of the lung markings, which had a tendency to become confluent. The root shadows were enlarged. Acinous and lobular exudative lesions were present. Some were confluent, forming larger areas of consolidation. The diminution in aeration depended upon the extent of the involvement. The peripheral portions of the lungs were not involved. These were superimposed upon diffuse interstitial changes. The findings were persistent and showed little or no regression. Progression was manifest with continued oil administration. A superimposed bronchopneumonia may be present which may resolve.

The diagnosis of oil aspiration pneumonia should always be considered when on serial studies there are evidences of a protracted bronchopneumonia, in an individual with a history of oil administration and difficulty in swallowing.

The incidence of oil aspiration pneumonia will be reduced if the use of oily medications and liquid petrolatum is kept at a minimum, or discontinued in the aged, bedridden, debilitated, and those suffering with dysphagia.

REFERENCES

1. Bromer, R. S., and Wolman, I. J. Lipoid pneumonia in infants and children. *Radiology*, 1939, *32*, 1–7.
2. Cannon, P. R. Lipoid pneumonia. *Arch. Path.*, 1935, *19*, 135–136.
3. Cannon, P. R. Problem of lipid pneumonia. *J. Am. M. Ass.*, 1940, *115*, 2176–2179.
4. Cannon, P. R., and Walsh, T. E. Lipoid pneumonia and some potential dangers of intranasal medication. *Internat. Clin.*, 1938, *3*, 109–115.
5. Freiman, D. G., Engelberg, H., and Merrit, W. H. Oil aspiration (lipoid) pneumonia in adults; clinicopathologic study of 47 cases. *Arch. Int. Med.*, 1940, *66*, 11–38.
6. Goodwin, T. C. Lipoid cell pneumonia. *Am. J. Dis. Child.*, 1934, *48*, 309–326.
7. Ikeda, K. Lipoid pneumonia of adult type (paraffinoma of lung). *Arch. Path.*, 1937, *23*, 470–492.
8. Laughlen, G. F. Pneumonia following nasopharyngeal injections of oil. *Am. J. Path.*, 1925, *1*, 407–414.
9. Paterson, J. L. H. Experimental study of pneumonia following aspiration of oily substances: lipoid cell pneumonia. *J. Path. & Bact.*, 1938, *46*, 151–164.
10. Pinkerton, H. Oils and fats: their entrance into and fate in lungs of infants and children; clinical and pathologic report. *Am. J. Dis. Child.*, 1927, *33*, 259–285.
11. Pinkerton, H. Reaction to oils and fats in the lung. *Arch. Path.*, 1928, *5*, 380–401.
12. Pinkerton, H., and Moragues, V. Paraffinoma of lung with secondary tubercle-like lesions in liver and spleen. *Arch. Path.*, 1940, *29*, 691–699.
13. Wolman, I. J., and Bayard, A. B. Experimental aspiration pneumonia; fluorescence and pathology. *Am. J. M. Sc.*, 1941, *202*, 542–553.
14. Young, A. M., Applebaum, H. S., and Wasserman, P. B. Lipoid pneumonia; report of case. *J. Am. M. Ass.*, 1939, *112*, 2406–2409.

Vol. 49, No. 2

ROENTGENOLOGIC CONSIDERATIONS IN THE DIAGNOSIS AND TREATMENT OF DIAPHRAGMATIC HERNIA*

By STUART W. HARRINGTON, M.D.
Division of Surgery, Mayo Clinic
ROCHESTER, MINNESOTA

ROENTGENOLOGY plays an important rôle not only in the recognition of diaphragmatic hernia but also in the determination of the type of treatment to be instituted.

The incidence of diaphragmatic hernia probably is no greater now than it was twenty years ago. At that time the condition was thought to be uncommon and its recognition during the life of the patient affected was rare. That diaphragmatic hernia is recognized more frequently in recent years is indicated by a review of the cases encountered at the Mayo Clinic between the years 1908 and 1941. From 1908 to 1925 inclusive (eighteen years) 30 instances of the condition were recognized clinically, and 14 patients were operated on. From 1926 to September 1, 1941 inclusive (about sixteen years), the condition was diagnosed more than 600 times and I have operated on 295 patients. This study, therefore, shows that twenty times as many diaphragmatic hernias were recognized in the last sixteen years as had been recognized in the previous eighteen years. I believe that the condition is even more common than the present records indicate. I have routinely examined the diaphragm in the course of other abdominal operations and occasionally have found a small hernia that had not been recognized clinically or roentgenologically before operation.

This marked increase in the frequency of the recognition is due primarily to the development of roentgenologic methods of diagnosis. The clinical recognition of diaphragmatic hernia on the basis of subjective symptoms alone is often difficult. The symptoms are complex because of the various structures involved in the hernia and depend on the amount of mechanical interference with the function of the herniated abdominal viscera, on the degree of the impairment of the normal function of the diaphragm and on the amount of increased pressure within the thorax causing impairment of respiration and circulation.

A study of the subjective symptoms in proved cases of diaphragmatic hernia has established a fairly definite clinical syndrome which enables the clinician in some instances to diagnose or at least to suspect the presence of a diaphragmatic hernia, but this clinical syndrome is never pathognomonic and requires collaboration by roentgenologic studies to establish a definite diagnosis before radical treatment should be instituted.

This is particularly true in certain kinds of hernia especially those of the esophageal hiatus type in which the symptoms frequently simulate those of other organic disease of the abdomen and thorax. In these hiatal hernias the stomach is usually the only abdominal viscus involved in the hernia. They are usually progressive sliding types of hernia and the symptoms vary with the degree and type of herniation; as the hernia progresses different clinical diagnoses may be suggested because of the changing symptoms which simulate those of other conditions. In a series of 295 cases which I have treated surgically it was found that an average of three previous erroneous clinical diagnoses had been made before a correct diagnosis had been established. The most common erroneous diagnoses in order of frequency were cholecystitis, cholelithiasis, gastric ulcer, duodenal ulcer, hyperacidity, secondary anemia,

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

cardiac disease, carcinoma of the cardia, stricture of the esophagus, appendicitis and intestinal obstruction. This is of particular surgical significance because 25 of these patients had been operated on previously for other conditions without relief of symptoms, but they did obtain relief after repair of the hernia.

Limited time will not permit me to go into detail concerning the clinical manifestations or surgical treatment of these hernias as I wish particularly to discuss some of the roentgenologic considerations which are of great assistance in the clinical recognition and surgical treatment of these hernias.

From the standpoint of treatment, diaphragmatic hernia is primarily a mechanical condition and the only treatment which will completely relieve the condition is operative repair of the abnormal opening or defect in the structure of the diaphragm. The indications for surgical treatment and the methods and technique of the surgical procedure depend on the type, situation and size of the defect in the structure of the diaphragmatic muscle; the kind and amount of abdominal viscera involved in the hernia, and whether or not the herniated viscera are enclosed in a hernial sac.

Many problems are associated in establishing an accurate diagnosis and selection of effective treatment to be instituted. These problems are best solved by the close cooperation with personal conferences between the roentgenologist, clinician and surgeon.

Roentgenography is not only of paramount importance in establishing a definite diagnosis of diaphragmatic hernia but it is of equal importance in ruling out other conditions in which the clinical symptoms often simulate those of diaphragmatic hernia, such as diverticulum of the lower end of the esophagus, diverticulum at the cardia of the stomach, cardiospasm, congenital short esophagus, and total or segmental eventration of the left hemidiaphragm. It is also of equal value in determining the type of diaphragmatic hernia which is present, the possible situation and size of the defect in the diaphragm, the amount of impairment of normal function of the defective diaphragm, and in determining the presence of other complicating or associated conditions of the esophagus and stomach such as ulceration, stricture and neoplasm. However, the presence of these lesions requires confirmation by esophagoscopic examination. I believe it is essential that all patients who have diaphragmatic hernia should not only have complete roentgenographic studies but also thorough esophagoscopic examination before surgical intervention. It is important to rule out the presence of any obstructing lesion of the esophagus in any case in which operation for diaphragmatic hernia is contemplated.

Stricture of the lower end of the esophagus is not uncommonly associated with esophageal hiatus types of diaphragmatic hernia; these strictures often result from cicatricial contraction of a traumatic ulcer caused by the hernia. If a stricture is present, it should be treated by dilatation before operation for the hernia. In some instances sufficient relief will be obtained by dilatation of the esophagus so that no surgical treatment is necessary for the hernia. In other instances the esophagus may be shortened so that the hernia cannot be reduced by surgical procedures.

Carcinoma of the lower end of the esophagus and cardiac end of the stomach may be associated with diaphragmatic hernia. This is probably an unrelated condition although it is possible that a carcinomatous change may take place in a traumatic ulcer resulting from the hernia. The presence of this lesion usually can be determined by roentgenologic examination, but if the malignant lesion is small, it may be overlooked because the barium filling the herniated viscera may obscure the defect particularly in the lower part of the esophagus. Malignant lesions in the cardiac end of the stomach may be overlooked because the marked deformity produced by the malposition of the stomach has obliter-

ated the normal outline of the stomach. The presence or absence of these lesions can be best determined by preoperative esophagoscopic examination with removal of tissue for diagnosis. I have operated on 3 patients who have had carcinoma in the lower end of the esophagus and 4 who have had carcinoma of the stomach associated with the hiatal hernia. In 1 case resection of the esophagus was performed and the other 2 cases were inoperable because of metastasis. In 3 of the 4 cases of carcinoma of the stomach, resection of the malignant lesion as well as repair of the hernia was performed and in 1 case the malignant lesion of the stomach was inoperable. It is also important to determine the presence of an obstructing lesion of the pylorus which may require additional surgical procedures at the time of repair of the hernia. I have operated on 2 patients who had obstructing ulcers of the duodenum and 1 who had carcinoma of the pylorus in addition to the hernia.

CLASSIFICATION OF DIAPHRAGMATIC HERNIA

Roentgenography is an important aid in classifying different types of hernia, but it is usually difficult to make a true classification on roentgenologic findings alone.

Much confusion has occurred because there is no standard nomenclature of classification of the different types of diaphragmatic hernia. Various classifications of these hernias have been made which are based on the embryologic and etiologic aspects, pathologic anatomy, the site of the opening in the diaphragm, the presence or absence of a sac, the content of the hernia and other factors. It is difficult or impossible to make most of these classifications clinically; accordingly, many of them are of little practical value.

From a clinical and surgical standpoint, the history of a preceding injury is helpful in establishing the diagnosis and determining the type, urgency and prognosis of the operative treatment. Because of the practical clinical and surgical significance of trauma as an etiologic factor, I have suggested that diaphragmatic hernia be classified into two main groups: nontraumatic and traumatic. I have subdivided these two groups according to the various types.

Nontraumatic Hernia. A nontraumatic diaphragmatic hernia may be congenital or acquired. If it is congenital, the hernia is attributable to embryologic deficiency and usually does not have a hernial sac. The more common sites of a congenital hernia which are present at birth in the probable order of frequency of occurrence are: (1) through the pleuroperitoneal hiatus (foramen of Bochdalek); (2) through the esophageal hiatus; (3) through an anterior substernal opening (foramen of Morgagni or Larrey's spaces), and (4) through the gap left by partial absence of the diaphragm, a gap which is usually situated in the posterior portion of the muscle.

If the hernia is acquired after birth, the sites of occurrence are: (1) through the esophageal hiatus (this type of hernia has a hernial sac); (2) through the region of fusion of the anlage of the diaphragm, and (3) at sites named under the congenital type in the foregoing paragraph.

Traumatic Hernia. Traumatic diaphragmatic hernia may be caused by direct or indirect injury, or by inflammatory necrosis of the diaphragm. In case of indirect injury of the diaphragm, the hernia may occur at any point, including points of embryologic fusion, but the most common sites are the dome and left posterior half of the diaphragm. On the other hand, the injury may occur in the right part of the diaphragm. This usually is the result of a severe, crushing injury. When the hernia occurs through the esophageal opening, there is a sac, but when it occurs through the leaf of the diaphragm there usually is no sac. In case of direct injury of the diaphragm, the hernia may occur at any point and is usually the result of penetrating wounds, such as those inflicted by a gun or knife.

Rupture of the diaphragm may be the result of inflammatory necrosis which, in turn, has been caused by subdiaphragmatic

TABLE I

DATA CONCERNING SITUATION, ETIOLOGY AND CONTENTS OF HERNIA

Site of Opening	Cases	Causation	Cases	Contents of Hernia	Cases
Esophageal hiatus	223	Congenital (history of trauma, 17)	223	Stomach (omentum) Stomach, omentum and spleen Stomach and colon	212 4 7
Short esophageal type	14	Congenital	14	Stomach only	14
Hiatus pleuroperitonealis	7	Congenital	7	Colon and small bowel Colon, small bowel, stomach and spleen	3 4
Absent posterior fourth of left diaphragm	5	Congenital	5	Stomach, colon, small bowel and spleen Colon and small bowel	3 2
Foramen Morgagni (subcostosternal)	4	Congenital	4	Omentum only Colon and omentum Omentum, cecum, appendix, colon and terminal ileum	2 1 1
Left hemidiaphragm (traumatic)	41	Trauma (indirect injury, 28; direct injury, 7); (inflammatory necrosis, 4)	41	Stomach only Stomach and colon Stomach, colon and small bowel Stomach, colon and spleen Stomach, colon, spleen and small bowel Stomach, colon, small bowel and liver Stomach, colon, small bowel, spleen and liver	5 10 7 2 9 4 4
Right hemidiaphragm	1	Trauma (indirect injury, 1)	1	Stomach, duodenum, colon, small bowel, liver (gallbladder) and head of pancreas	1
Totals	295		295		295

abscess, or, again, rupture may follow necrosis caused by drainage tubes which have been introduced into empyematic cavities. In these cases the opening usually is situated in the posterior part of the diaphragm and there is no hernial sac.

Contents of Hernia. In general, the various types of diaphragmatic hernia can be divided clinically into two main classes, depending on the abdominal viscera which are involved. In the first class the stomach is the only abdominal viscus incorporated in the hernia; the hernia usually occurs through the esophageal hiatus. In the second class, the intestines with or without the stomach and other abdominal viscera are included in the hernia. Such a hernia usually is of traumatic origin and is caused by laceration of a normal diaphragm. It also may be of congenital origin and may result from structural deficiency of the diaphragm.

Types of Hernia Encountered in Clinic Series. In my experience in 295 cases in which surgical treatment was employed, the most common types of hernia are esophageal hiatus hernia, pleuroperitoneal hiatus hernia, hernia attributable to congenital absence of the posterior portion of the diaphragm, subcostosternal hernia and

traumatic hernias caused by direct or indirect injury and those caused by inflammatory necrosis (Table 1).

stomach usually is the only abdominal viscus involved in the hernia. This type of hernia may progress until the entire stom-

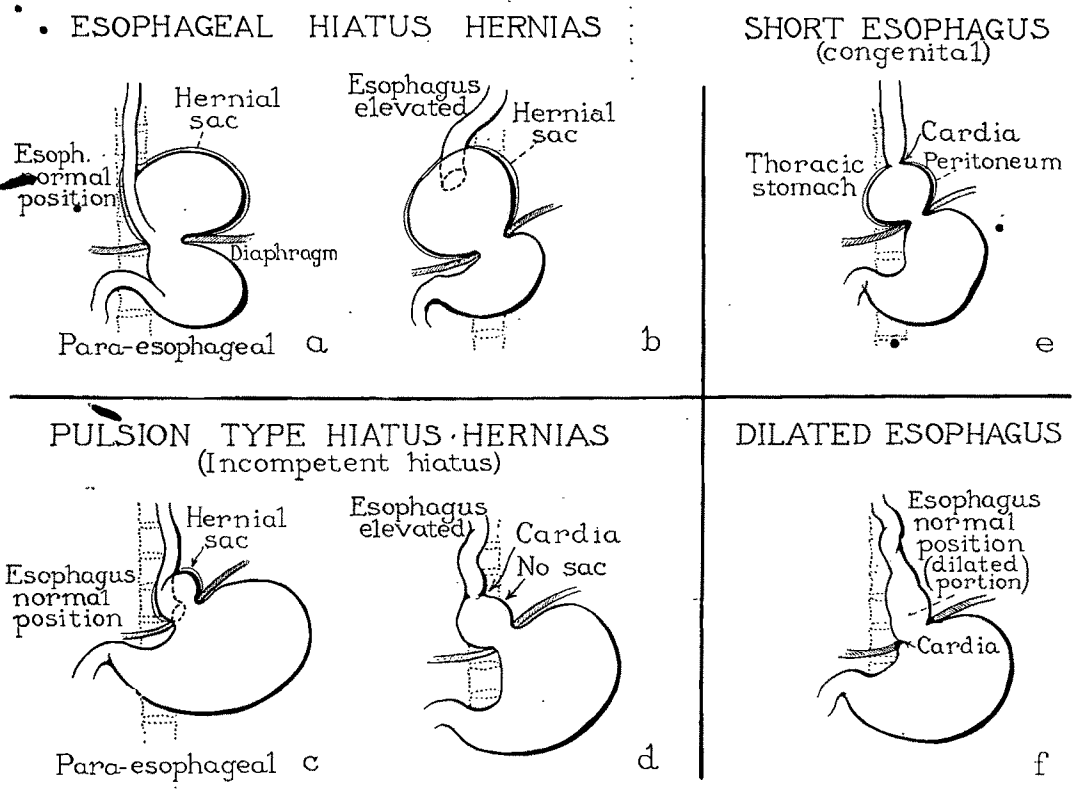


FIG. 1. Diagrammatic drawings of different types of esophageal hiatus hernia and some of the conditions which may simulate hiatus hernias roentgenologically. *a*. Esophageal hiatus hernia with herniation of the cardiac end of the stomach through the esophageal hiatus. Esophagus in normal position (para-esophageal hernia). *b*. Esophageal hiatus hernia in which there is herniation of the greater portion of the stomach through an enlarged esophageal hiatus into the posterior mediastinum and associated elevation of the esophagus. *c*. Slight protrusion of the cardia of the stomach through the hiatus with slight elevation of the lower part of the esophagus to the upper margin of the esophageal hiatus. This is a pulsion type of hernia with incompetent hiatus. *d*. Protrusion of cardiac end of the stomach through the esophageal hiatus and marked elevation of the esophagus into the posterior mediastinum; incompetent hiatus. *e*. Congenital, short esophagus with partial thoracic stomach. This is not a true hernia. *f*. Dilatation of the lower end of the esophagus, cardiac antrum. This is not a hiatus hernia. (From Harrington, S. W. Diagnosis and treatment of various types of diaphragmatic hernia. *Am. J. Surg.*, 1940, *50*, 377–446. Courtesy of the American Journal of Surgery, Inc.)

ESOPHAGEAL HIATUS HERNIAS

Esophageal hiatus hernia is the most common kind of herniation occurring through the diaphragm that is found among adult persons (Fig. 1). This type of hernia is slowly progressive and is a sliding herniation of the stomach into the posterior part of the mediastinum. It may push into either or both sides of the thoracic cavity, but does not enter the pleural cavity. The mach is contained within the hernial sac; the colon, omentum, and occasionally the spleen also may be drawn into the hernial sac.

I believe it is best to classify all true hernias through the esophageal hiatus under the one term "esophageal hiatus diaphragmatic hernia." True esophageal hiatus hernias can be classed into two types: in the first type the esophagus is of normal

length and its lower end is not elevated above the diaphragm, but a portion of the stomach has herniated into the posterior mediastinum, beside the esophagus. This type of hernia is often designated as para-esophageal hiatus hernia. The hernias are usually small to moderate in size and rarely involve more than a fourth to a half of the cardiac end of the stomach, which is contained in the hernial sac. About a third of the esophageal hiatus hernias on which I have operated were of this type.

In the second type of esophageal hiatus hernia, the esophagus is of normal length but its lower end is elevated above the level of the diaphragm, and the herniated stomach is in the posterior mediastinum. The size of the hernias is usually larger than that of the first type. From a third of the stomach to the entire stomach, portion of the omentum and occasionally a portion of the colon, are within the hernial sac. These hernias usually fill the entire mediastinum and generally project into the left side of the thoracic cavity but they may project into the right side of the thoracic cavity or into both sides. Hernias of this type constitute about two-thirds of the esophageal hiatus hernias on which I have operated.

The essential difference between these two types is one of degree rather than any fundamental difference in origin. Inasmuch as these hernias are progressive in character and are in reality a sliding type of hernia, hernias of the first type may ultimately develop into those of the second type as more of the stomach is included in the hernial sac. In many cases of esophageal hiatus hernia there is dilatation of the lower end of the esophagus. This is usually more marked in the larger types of hiatus hernia.

With the more frequent roentgenologic recognition of small esophageal hiatus hernias in the last few years, two additional types have been recognized which may be considered pulsion types of esophageal hiatus hernia. In these types a small portion of the cardiac end of the stomach projects through the esophageal hiatus. These hernias are probably attributable to atrophy of the elastic fibers of the diaphragmatico-esophageal membrane together with relaxation of the circular muscle surrounding the esophageal opening, with a resultant incompetent hiatus. Recognition and differentiation of these two types are often difficult by roentgenologic examination alone. The establishment of the diagnosis is aided by an esophagoscopic examination which is often essential in arriving at an accurate diagnosis. These hernias are more commonly seen among elderly persons. In many instances the finding of these hernias is incidental, for the patients do not present any subjective symptoms. However, in the instances in which the symptoms are severe and do not respond to conservative measures, surgical intervention is necessary for relief.

Hernias of the third type closely simulate the para-esophageal type of hernia except that they are relatively small. A definite hernial sac is beginning to form. The esophagus is only slightly elevated; the abdominal portion is elevated to the superior border of the diaphragm. The hernia may remain small or it may develop into a true para-esophageal hernia.

In the fourth type the entire hiatus is incompetent, the cardiac end of the stomach protrudes like a funnel above the diaphragm and there is a comparable elevation of the esophagus which enters the apex of the protruded portion of the stomach. This type does not have a true hernial sac and may not be considered a true hernia. This type of hernia can be distinguished in diagnosis from a congenital short esophagus with a part of the stomach in the thorax and dilatation of the lower end of the esophagus. This is best accomplished by an esophagoscopic examination to determine the length of the esophagus.

CONGENITAL SHORT ESOPHAGUS

In congenital short esophagus because of congenital malformation, the esophagus is not long enough to permit the stomach to reach its normal position below the diaphragm. The stomach is held suspended in the posterior mediastinum above the diaphragm. In this type of case the abnormal

ity is often considered to be an esophageal hiatus hernia, but it is not a true hernia as the stomach has never been below the diaphragm. I believe the condition could be better described as a congenitally short esophagus with partial thoracic stomach. In my experience this condition is relatively rarely found at operation. I have operated on 11 patients who presented all of the roentgenologic signs of short esophagus but at the time of the operation I found that in 4 cases the esophagus, although its lower end was above the diaphragm, was sufficiently long to reach below the diaphragm when the herniated portion of the stomach was placed below the diaphragm. Of the remaining 7 cases, in 3 there was a slight shortening of the esophagus associated with herniation of the cardiac end of the stomach and the remaining 4 were cases of true short esophagus with partial thoracic stomach. In all but one it was possible to bring the stomach entirely below the diaphragm after separation of the attachments around the hiatus and the elevation of the diaphragm resulting from interruption of the phrenic nerve. In 1 case it was impossible to bring the stomach entirely below the elevated diaphragm and it was necessary to suture a small portion of the cardia into the hiatus when the hiatus was closed. This indicates that it is not always possible by roentgenologic methods to determine the type of hernia present. I believe that this condition, although rare, is an entity and should not be grouped with the true esophageal hiatus hernias.

This condition of short esophagus, from an etiologic standpoint falls into two classes: first, that in which the esophagus is congenitally short, which has been described, and second, that in which ulceration and occasionally malignant neoplasm of the esophagus have caused cicatricial contraction of the lower end of the esophagus. The cicatricial contraction draws the cardia of the stomach above the diaphragm, and the condition usually is associated with stenosis of the lower part of the esophagus.

In considering cases of short esophagus from a surgical standpoint, it is important not to confuse them with true esophageal hiatus hernias, for their surgical management is entirely different. In cases of true hernia, the surgical problem is that of replacement of the herniated viscera, removal of the hernial sac and repair of the abnormally enlarged esophageal hiatus. In cases of congenital short esophagus the surgical problem is that of reconstruction and elevation of the diaphragm to a position above the stomach; this can be accomplished if the congenital shortening of the esophagus is not too great. In those cases in which the stomach is elevated above the diaphragm because of traction of cicatrices following ulceration, the symptoms usually are relieved by dilatation of the stenosed esophagus. In those cases due to malignant neoplasms, radical removal of the lesion of the esophagus is to be considered.

DILATATION OF THE LOWER END OF THE ESOPHAGUS WITH RELAXATION OF THE CARDIA OF THE STOMACH

This condition not uncommonly simulates esophageal hiatus hernia of the pulsion types both roentgenologically and clinically. In order to establish a definite diagnosis it is usually necessary to examine the esophagus with an esophagoscope as well as to carry out roentgenologic examination. At the time of the esophagoscopic examination, a specimen of tissue can be removed from the wall at the site of dilatation and studied to determine whether it is squamous cell epithelium of the esophagus or gastric mucosa of the stomach. It is important to differentiate dilatations of the lower part of the esophagus from hiatus hernias as surgical intervention is not indicated in cases of dilatation of the esophagus.

CONGENITAL DIAPHRAGMATIC HERNIA DUE TO STRUCTURAL DEFICIENCIES OF THE DIAPHRAGM (PLEUROPERITONEAL HIATUS HERNIA AND CONGENITAL ABSENCE OF POSTERIOR PORTION OF DIAPHRAGM)

Congenital diaphragmatic hernias attributable to congenital deficiencies of the diaphragm are of two principal types. The

first type is the pleuroperitoneal hiatus type of hernia and is due to a lack of fusion of the pleuroperitoneal membrane and septum transversum which results in an opening through the diaphragm. The second type, which is the congenital absence of the posterior portion of the diaphragm, is a much larger deficiency caused by lack of formation of the portion of the diaphragm resulting from the pleuroperitoneal membrane and possibly the wolffian body. There are various gradations of the amount of defect so that the size of the opening varies with the amount of the deficiency of the formation of the diaphragm.

The opening in the first type is usually situated in the costal angle posteriorly at the junction of the middle and posterior thirds of the diaphragm. This opening may extend to the chest wall and is usually somewhat triangular with the apex toward the middle portion of the diaphragm, or it may be entirely within the structure of the diaphragm where it is usually more or less elliptical. In this type of hernia the abdominal viscera which usually are involved in the hernia are the cecum, appendix, the ascending colon, greater portion of the transverse colon and practically all of the small bowel. In the larger hernias which present posteriorly, the spleen may be involved. The stomach is usually in the abdomen; it may be dilated markedly and at times extends to the pelvis.

In the second type of hernia associated with congenital absence of the posterior portion of the diaphragm, the same abdominal viscera are involved as in the pleuroperitoneal hiatus type of hernia; these are the ascending and transverse colon, small bowel and in addition usually the stomach, spleen and left kidney. The roentgenologic examination is often misleading in this type of hernia, for in many instances at the time of the roentgenologic examination the stomach is found to be in the abdomen and at the time of operation it is found to be herniated in the left side of the thorax. This, I believe, is due to the weight of the barium which causes the stomach to drop into the abdomen where undoubtedly it is a great deal of the time during life. It doubtless goes back and forth through the large opening posteriorly at the point where it extends up to the esophageal hiatus. Because of the roentgenologic findings of the stomach in the abdomen, this type of hernia may be thought to be a true pleuroperitoneal hiatus type of hernia rather than that produced by congenital absence of a larger portion of the diaphragm. The position of the left kidney as shown by the renal shadow or pyelogram may be helpful in differentiating between these types of diaphragmatic hernia. In the pleuroperitoneal hiatus type of hernia the kidney is in its normal position below the diaphragm. In the type of hernia resulting from the absence of the posterior portion of the diaphragm, the kidney is usually elevated to a position above the normal diaphragm in the lower part of the thorax.

It is often difficult to determine the function of the diaphragm in hernias caused by structural deficiencies as the motion is usually obscured by the enormous amount of viscera contained in the thorax. When it can be visualized, there is usually some impairment in normal function.

These hernias do not have a hernial sac and the abdominal viscera are in direct contact with the thoracic cavity. They produce marked or complete collapse of the left lung and often marked shift of the mediastinum to the right. This shifting of the mediastinum depends on the amount of distention of the herniated viscera.

I believe that operation should be performed for these congenital types of hernia as soon after birth as the condition is recognized, for the longer the interval between birth and operation the greater the technical difficulties and the greater may be the hazard of operation. Inasmuch as a high percentage of infants born with these types of congenital hernia die the first few hours or days of life from cardiac or respiratory difficulty, I believe operation should be performed as soon as a diagnosis is established; which often can be done by taking

a roentgenogram of the thorax. At birth the defect is relatively smaller in proportion to the size of the thorax than it is later in life. In infants who live, the chest wall grows away from the posterior margin of the defective diaphragm because there is no posterior attachment. The opening therefore which must be closed is much larger as the child becomes older. Even though the diaphragmatic muscle is relaxed by interruption of the phrenic nerve, there may not be sufficient diaphragm to span this opening. In some instances an extrapleural rib resection also is necessary to narrow the diameter of the thorax in order to close the opening.

One of the chief dangers associated with the repair of these hernias is marked alteration of intrathoracic or intra-abdominal pressure. It is important in these cases that the respiratory function be maintained by positive pressure during the operation and that at the completion of the operation a negative pressure be obtained and secured in the thoracic cavity. A roentgenogram should be taken at the completion of the operation to see that there is no shift of the mediastinum caused by the pneumothorax. I do not permit the patient to leave the operating table until I have seen the roentgenogram. If there is any shift in the mediastinum, more air is withdrawn to maintain the mediastinum in the midline as shown by further roentgenograms.

SUBCOSTOSTERNAL (FORAMEN OF MORGAGNI) DIAPHRAGMATIC HERNIA

The clinical recognition of this type of hernia is usually entirely dependent on roentgenologic examination. From the roentgenologic standpoint the diagnosis may be established readily or it may be impossible to establish a definite diagnosis depending on the kind of the abdominal viscera involved in the hernia. The defect in the diaphragm is anterior at the attachment of the diaphragm to the thoracic wall. The hernial opening may be bilateral, but it is usually unilateral and a little to the right of the midline beneath the lower part of the sternum and right costal cartilages. The abdominal viscera usually involved in the hernia are the omentum and the omentum and colon which are enclosed in a hernial sac of peritoneum. This extends into the thoracic cavity beneath the pleura but does not enter the true pleural space.

When the colon is involved in the hernia the roentgenologic diagnosis is readily established. The colon is visualized immediately beneath the right anterior wall of the chest and may extend to the apex on the right side of the thoracic cavity. In one instance in which there was a nonrotation of the colon, I have seen the ileocecal coil in this type of hernia.

When the omentum is the only abdominal structure involved in the hernia, the roentgenologic diagnosis is difficult and may be impossible to establish definitely. The roentgenologic findings are those of increased density at the cardiophrenic angle anteriorly, usually on the right and are commonly thought to be due to an intrathoracic tumor. In some instances the true diagnosis can be suspected by roentgenologic examination of the colon which shows the colon drawn up toward the abdominal side of the opening but the elevated portion of the colon is not always present and the colon may be in normal position in the abdomen. I have operated on 3 patients who had hernias of this type which had been diagnosed elsewhere as intrathoracic tumors. In 1 of these the diagnosis of intrathoracic tumor was confirmed at the Clinic. On transpleural exploration the lesion was found to be an omental subcostosternal hernia. I also have operated on 1 patient who was thought to have an omental subcostosternal hernia, but proved to have a cystic mediastinal tumor at the costophrenic angle anteriorly. If the omental hernia is large, the clinical symptoms also may suggest the diagnosis of thoracic tumor because of the pulmonary symptoms due to pressure causing partial collapse of the lung. In the smaller types of hernia containing omentum only, there are usually no sub-

jective symptoms and the diagnosis is usually established at operation.

TRAUMATIC DIAPHRAGMATIC HERNIA

These hernias may result from direct or indirect injury to the diaphragm and are probably the most readily recognized clinically as well as roentgenologically of all types of diaphragmatic hernia. The hernia may occur in either the right or the left side of the diaphragm but it occurs much more commonly in the left side. The laceration may occur in any portion of the diaphragm but it is most common in the posterolateral portion and dome of the diaphragmatic muscle. The laceration may extend across the entire leaf of the diaphragm and occasionally extends into the opposite side of the diaphragm. These lacerations occasionally split the esophageal hiatus but in most instances the circular muscle of the hiatus remains intact. There is usually only one opening but there may be multiple openings. The laceration is usually in the suspended portion of the diaphragm but occasionally may involve the attachment of the diaphragm to the wall of the chest. In some instances the attachments may be almost completely torn from the chest wall. The laceration involves the entire width of the diaphragmatic muscle producing a direct communication between the abdominal and the thoracic cavity and there is no hernial sac. The condition may be more properly termed an evisceration than a true hernia.

Any of the abdominal organs except those in the pelvis may be involved in these hernias. The most common are the stomach, large and small bowel, spleen and liver. Roentgenologically the entire thoracic cavity is seen to be filled with hollow viscera which may extend to the apex of the thorax causing almost complete collapse of the lung with marked displacement of the mediastinum. In lacerations in the right half of the diaphragm the shadow of the liver may be seen above the diaphragm. It is usually difficult to determine the situation of the laceration in the diaphragm or the function of the diaphragm by roentgenologic examination because of the presence of the mass of herniated viscera which obscures the diaphragmatic muscle. Lacerations of the diaphragm involving the esophageal hiatus may be suggested roentgenologically by elevation of the lower end of the esophagus with the cardia of the stomach into the thoracic cavity.

Inflammatory Necrosis. This type of hernia may be termed a "traumatic hernia" and is one of the rarest types of diaphragmatic hernia. It is produced by an inflammatory necrosis of the diaphragm caused by rupture of a subphrenic abscess through the left half of the diaphragm. The acute condition may have preceded the diagnosis of hernia by months or years. These hernias usually occur in the dome of the diaphragm and do not involve the hiatus; they do not have a hernial sac. The stomach or stomach and bowel may be involved in the hernia. While the diagnosis is essentially a clinical consideration these hernias do have some suggestive roentgenologic findings; namely, there is a relatively small portion of stomach or bowel involved in the hernia; a small segment of stomach may be herniated through the diaphragm, and the herniated viscera are very adherent to the hernial opening and to the under surface of the lung.

These hernias often present a difficult surgical problem because of the enormous number of adhesions fixing the herniated abdominal viscera to the diaphragm, which require careful dissection. There is often some loss of structure and thinning out of the diaphragmatic muscle. These hernias are repaired by overlapping the margins of the opening after carefully dissecting the viscera from the diaphragm and the margins of the opening.

POSTOPERATIVE MANAGEMENT

Roentgenography is also important in the immediate and subsequent postoperative management of surgical patients.

At the completion of all operations for diaphragmatic hernia, I routinely have roentgenograms made and read before the

patient is taken from the operating room. It is extremely important to determine the presence or absence of any abnormal condition or position of the intrathoracic viscera and if some abnormal condition is present, it should be corrected before the patient leaves the operating table.

Two of the more important immediate postoperative conditions which imperil the recovery of the patient following operation are displacement of the mediastinum to the side opposite the operation, and pulmonary congestion. If these conditions are present, they seriously interfere with cardiac and respiratory function and the result may be death if they are not immediately relieved. Mediastinal displacement is due to pneumothorax and must be relieved immediately by the withdrawal of sufficient air to produce a negative intrathoracic pressure and bring the mediastinum to the midline.

Pulmonary congestion is due to the retention or aspiration of secretions and is best relieved by immediate bronchoscopic aspiration of the lung.

Patients who require immediate postoperative treatment should have a second roentgenogram made and read after the treatment has been instituted to be certain the condition has been corrected before they are taken from the operating table.

One of the important subsequent postoperative conditions that may develop is pleural effusion from trauma of the pleura. The pleural effusion may be slight and gradually absorb and require no treatment. It may become progressively more marked causing respiratory and cardiac difficulty and require pleurocentesis.

COMMENT

I do not believe it is possible to overestimate the value of roentgenography in the diagnosis and treatment of diaphragmatic hernia. The advent of roentgenography made possible the clinical diagnosis. The marked improvement in roentgenologic methods of diagnosis which has taken place in recent years is of great value in the clinical and surgical management of this group of cases. I am certain that increased knowledge which is now obtainable before operation in regard to these hernias is an important factor in decreasing the operative mortality which is relatively small considering the magnitude of many of these operative procedures. In this series of 295 operated cases there were 12 deaths, or a mortality of 4 per cent.

DISCUSSION

DR. B. N. CARTER, Cincinnati, Ohio. It is fitting that the subject of hernia through the diaphragm be discussed before a group of roentgenologists, for it is largely due to the improvement in their technique, to their interest, and to their endeavor that diaphragmatic hernia has reached its present position of prominence in the surgical world. In many instances the diagnosis based on signs and symptoms is extremely difficult because the disease so readily simulates many other conditions in the respiratory tract or gastrointestinal symptoms. Both roentgenography and roentgenoscopy are important in establishing the diagnosis, but even with their help the diagnosis may often be missed or long delayed. It is the old story of first thinking of the disease, after which the diagnosis may be ruled in or out. We are now becoming more and more conscious of the condition of diaphragmatic hernia and consequently we should diagnose it more and more accurately in the future.

Few surgeons have been as fortunate as Dr. Harrington in seeing and treating such a large number of cases of diaphragmatic hernia. He has been able to formulate certain rules of management and of operation which have been of the greatest benefit to surgeons everywhere; for example, his classification of diaphragmatic hernia is sound and is the accepted one at present. Many points in the technique of his operation have been universally adopted. Rather than attempt a general discussion of his paper, I will focus my attention on one or two aspects of the subject.

In the first place, it seems to me to be essential to look at congenital diaphragmatic hernia from the point of view of the *age* of the given patient as well as of the anatomy of the condition. I say this because the treatment of a given case depends considerably on this fact. It has been estimated that 75 per cent of infants with congenital hernia through the diaphragm die before

the end of their first month of life, and that a further number of the remaining 25 per cent die of their disease during the early years of childhood. On the other hand, if a given patient has survived his childhood, the chances are great that he will live out his normal span of life in spite of the hernia, though he may be greatly inconvenienced by it. The surgical significance of these facts from the point of view of treatment is very clear, namely, infants born with diaphragmatic hernia have their best chance of survival if they are operated upon as promptly as possible after birth, whereas older patients may be temporized with, treated palliatively, and operated upon when such a procedure is indicated. There is obviously little excuse for expectant treatment in the case of infants with diaphragmatic hernia if 75 per cent of them are going to die under such therapy. Infants stand operative procedures surprisingly well and I feel that early operation offers them their best chance. This fact is not appreciated widely enough either by pediatricians or by general surgeons.

In the second place, I would like to say a word or two about congenital diaphragmatic hernia occurring on the *right* side. These hernias are rare, and are said to occur in about 9 per cent of all congenital hernias. Such hernias usually occur through the parasternal space, though occasionally they may be seen to enter the chest through the pleuroperitoneal space. The presence of the liver beneath the diaphragm is probably the reason for the small number of hernias occurring through the right diaphragm. The most common viscus involved in right-sided hernia is the transverse colon, and since the opening in the diaphragm at the parasternal space is small, obstruction is very apt to occur in these cases. The two parasternal hiatuses lie one on each side of the xiphoid process. A hernia coming through the left hiatus may push its way into the right chest, and vice versa. These two facts are strong indications for the abdominal operative approach to parasternal hernias. A transthoracic approach is difficult because the opening in the diaphragm is inaccessible through the thorax and also because, if the hernia comes through an opening on the left side and has pushed its way into the right, obviously one would have to go through the anterior mediastinum into the opposite chest in order to close the defect.

Personally, I prefer and have used the transthoracic approach in all the cases of hernia through the diaphram which I have operated upon, except the parasternal ones. I like this approach because it gives a wide and easy exposure to the diaphragm, because sutures can be placed accurately from above without fear of damaging the heart, great vessels, and esophagus. I recall vividly one traumatic diaphragmatic hernia which I did transthoracically. The tear in the diaphragm extended right to the lower surface of the pericardium. Had I been below the diaphragm, I believe I would certainly have damaged the heart in my attempt to suture the rent in the diaphragm. If there are adhesions present, as is commonly the case in chronic traumatic hernia, the transthoracic approach is much preferable. It is said that reduction of the hernial content is difficult through the opening in the diaphragm if one is working through the thorax. I have not found this to be the case except in one instance where, after enlargement of the ring, the hernia was readily reduced. By opening the ring widely one can explore the upper abdomen easily and can be sure that the replaced intestine is in satisfactory position. If the transthoracic approach is used, it is a very simple matter to crush the phrenic nerve at this operation rather than perform a phrenicotomy in the neck. We crush the phrenic nerve in all of our operations and feel that this is important. The rest afforded the diaphragm makes the suturing of it a simpler matter and aids in the healing of the diaphragm.

Dr. Harrington (closing). I thank Dr. Carter for his discussion and am pleased that he has emphasized the importance of early operation in congenital diaphragmatic hernia and the difficulties which are occasionally encountered in establishing a diagnosis in the subcostosternal types of hernia, particularly in those cases in which the omentum is the only abdominal structure involved in the hernia. In these cases it is often impossible to differentiate this type of hernia from intrathoracic tumor. However, when the colon is involved in this type of hernia they are probably the most easily recognizable of all types of diaphragmatic hernia by the injection of opaque material into the colon showing it extending above the diaphragm from the right cardiophrenic angle along the anterior chest wall and usually extending into the right thoracic cavity.

VOL. 49, NO. 2

CARCINOMA OF THE HEAD OF THE PANCREAS DEMONSTRATING THE NEW SIGNS IN ROENTGEN DIAGNOSIS*

CASE REPORT

By PAUL S. FRIEDMAN, M.D.
PHILADELPHIA, PENNSYLVANIA

THE roentgen diagnosis of enlargement of the head of the pancreas, and in turn, of carcinoma of the head of the pancreas, was traditionally dependent upon gross changes such as marked widening of the duodenal curve. Recently, however, largely due to the efforts of Frostberg and Feldman, closer attention has been paid to the early mucosal changes in the duodenum accompanying enlargement of the head of the pancreas. They have, in particular, described an inverted 3 pressure filling defect, characteristically seen along the internal aspect of the duodenal curve, as well as accompanying distortion of its mucosal pattern, with changes in contour of the ampullary portion of the duodenum.

The following case report is interesting because of its demonstration of these signs. The operative and autopsy data are also interesting.

CASE REPORT

A white male, aged fifty-seven, was admitted to Jefferson Hospital with a history of persistent epigastric discomfort of about seven months' duration, accompanied by a gradually progressive yellowish discoloration of the skin, generalized pruritus, and weight loss of about 30 pounds.

Physical examination revealed the presence of emaciation and jaundice. The abdomen was scaphoid in type with moderate epigastric tenderness. The liver was firm and enlarged, extending to the right iliac crest.

Laboratory studies revealed a prolongation of prothrombin time which was remedied by the administration of vitamin K. Liver function was depressed, with a positive direct Van den Bergh, and a quantitative Van den Bergh of 16.4 mg.

Roentgen examination of the gastrointestinal tract revealed the pyloric antrum to be deformed and widened apparently by extrinsic pressure. The descending duodenum was noted to be somewhat rotated, with widening of its mucosal folds. On its lateral aspect, corresponding to its posterior wall, there was present a figure 3 filling defect (see Fig. 1 and 2). Incidentally, diverticula of the descending duodenum and upper jejunum were visualized.

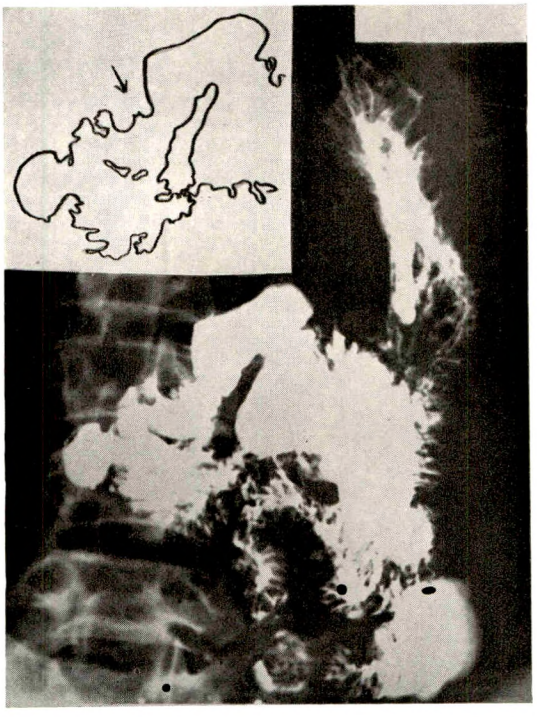


FIG. 1. Demonstrating the figure 3 defect along the external aspect of the duodenum (see diagram).

At operation, a distended gallbladder with a dilated common bile duct about 5 cm. in diameter was found. The head of the pancreas formed a stony hard mass which involved the ampulla of Vater. On the under surface of the liver a firm white nodule was present. A choledocho-duodenostomy was performed.

* From the Department of Radiology, Jefferson Hospital and Medical College, Philadelphia.

The patient died a week following operation, after a comparatively mild postoperative course with symptoms of fever, dyspnea, non-productive cough and chest pain.

Postmortem examination revealed an adenocarcinoma of the head of the pancreas, with metastases to the liver and hepatic hilar lymph nodes. The head of the pancreas was firm and enlarged, measuring 5 cm. in diameter. The immediate cause of death was an acute fibrinopurulent peritonitis, apparently due to leakage from the site of the choledocho-duodenostomy.

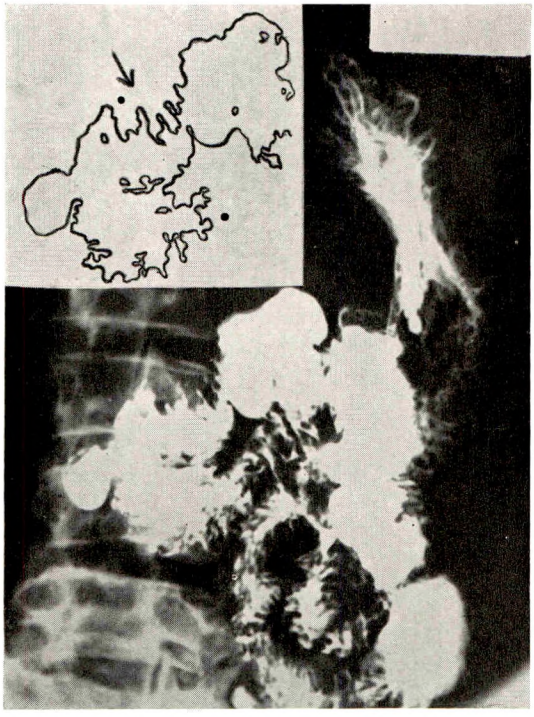


FIG. 2. Demonstrating distortion of the mucosal pattern of the duodenum (see diagram). Note the diverticulum along the external aspect of the duodenum.

COMMENT

A case of carcinoma of the head of the pancreas is presented, which demonstrates distortion of the mucosal folds of the duodenum, evidence of rotation of the duodenum and a figure 3 filling defect. This defect apparently represents evidence of pressure of the enlarged head of the pancreas upon the ampullary portion of the duodenum. In this case, although it was not as sharply demarcated as in some of the cases of Frostberg and Feldman, it was well visualized. However, instead of appearing as an inverted figure 3 defect along the internal aspect, it appeared as a figure 3 defect along the external aspect. This was due to the factor of rotation; the defect apparently represented pressure along the posterior wall of the descending duodenum, but due to the accompanying rotation of the duodenum it appeared externally. This rotation was further indicated by the presence of the duodenal diverticulum along the external aspect; it probably originated internally and was rotated externally.

Thus, the roentgen diagnosis here was largely dependent upon the distortion of the mucosal folds of the duodenum, evidence of rotation of the duodenum with displacement of a diverticulum to an external position; the presence of the figure 3 defect was interesting confirmatory evidence. Similar pressure upon the pyloric antrum was evident.

REFERENCES

1. FELDMAN, M. Roentgen diagnosis of early enlargement of head of the pancreas. *Am. J. Digest. Dis.*, 1939, *6*, 237–238.
2. FELDMAN, M. Slight enlargement of head of the pancreas: associated pathologic changes in the duodenum. *Radiology*, 1941, *36*, 224–229.
3. FROSTBERG, N. Characteristic duodenal deformity in cases of different kinds of perivaterial enlargement of the pancreas. *Acta radiol.*, 1938, *19*, 164–173.

Vol. 49, No. 2

THE DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC

WITH SPECIAL REFERENCE TO (1) ITS DIFFERENTIATION FROM CERTAIN DEGENERATIVE LESIONS OF THE DISC AND ITS RELATED STRUCTURES AND (2) THE INTERPRETATION OF CONTRAST MYELOGRAPHY*

By THOMAS HORWITZ, M.D.†
PHILADELPHIA, PENNSYLVANIA

AN EXTENSIVE literature has accumulated on the subject of lesions of the intervertebral disc and its adjacent structures, more particularly with reference to posterior protrusions of the intervertebral disc into the vertebral canal and/or intervertebral foramen (Saunders and Inman,[17] Bradford and Spurling[2]). Large series of cases, in which this latter lesion has been demonstrated at operation as a cause of low backache and the sciatic syndrome, have been reported from certain clinics (Love and Walsh,[15] Barr and Mixter,[1] Bradford and Spurling[2]). Although the diagnostic criteria for this lesion have been specifically defined, and although the enthusiasm of certain investigators regarding the beneficial results following laminectomy in these cases is reflected in their clinical reports, there remain certain features regarding both phases, diagnosis and therapy, which require clarification.

There are some observers (Semmes,[19] Bradford and Spurling,[2,20] Spurling and Grantham,[21] Dandy[5]) who feel that the diagnosis and accurate localization of posterior protrusion of the intervertebral disc may be determined in a high percentage of cases from the clinical signs alone, with or without the aid of a spinal fluid examination. Most investigators, however, continue to rely on the contrast myelographic study as an aid in the diagnosis and localization of this lesion. This examination, despite the criteria specified by Hampton and Robinson,[12] Robinson,[16] Hampton,[11] Camp,[3,4] and others, has not proved to be an infallible diagnostic measure even in their experienced hands, although the preoperative roentgenographic diagnoses have been substantiated at operation in well over 90 per cent of their cases. Such errors, however, as positive myelographic interpretations with negative operative findings, or negative myelographic interpretations in the presence of intraspinal lesions, demand elucidation. These difficulties are exemplified in the cases in Figure 1.

There are a certain number of cases of low back pain, with or without the sciatic syndrome which, in my experience and in the experience of others, have failed to make a satisfactory recovery, despite the removal of a demonstrable posterior protrusion of the intervertebral disc. The explanations offered for such failures have varied: the posterior disc protrusion might have recurred; there might have been other disc protrusions at other levels that were not recognized; the posterior disc protrusion might have been only partly or not at all responsible for the disabling syndrome; or the type of surgery performed (laminectomy) might have been insufficient. With regard to this last suggestion, it is noteworthy that Barr and Mixter[1] observed, in an extensive series of cases, that only 52 per cent of those patients who had had laminectomies without subsequent spine fusion had no complaints, but that 73 per cent of those who had had the combined operation considered their backs of normal strength. While Farrell and MacCracken[9] have even suggested that spine fusion alone

* From the Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia; Director: Dr. J. Parsons Schaeffer.
† Corinna Borden Keen Research Fellow, Jefferson Medical College, Philadelphia.

might be as effective as laminectomy and spine fusion, it is unlikely that successful treatment of the root compression could omit the removal of the protruding disc material that is compressing the sciatic nerve components.

The following observations by the writer, in one hundred spines of humans whose ages had varied between forty and eighty years, may throw some light on these problems.

THE SIGNIFICANCE OF DEGENERATIVE LESIONS OF THE INTERVERTEBRAL DISC AND ITS RELATED STRUCTURES IN THE DIFFERENTIAL DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC

It is essential to recognize that other lesions, which are largely the result of degenerative processes that involve the intervertebral disc, ligamentum flavum, and the adjacent bony structures, may produce defects in an intraspinal column of contrast medium that are characteristic of an extradural lesion. These lesions are often asymptomatic (Horwitz,[13] Duncan, Seybold, Hotchkiss and Kahler[7]).

1. Posterior bulging of the entire intervertebral disc, without localized herniation, is a common finding in adult cadaver material. The entire disc, in these instances, invariably shows advanced degenerative disease. The posterior protrusion is formed not only by thinned disc material bulging dorsalward, but also by the underlying hypertrophied posterior margins of the adjacent vertebrae. In my material, posterior bulging of the annulus fibrosus across the entire width of the disc, without true herniation, was observed in 25 instances between the fifth lumbar and first sacral vertebrae, in 22 instances between the fourth and fifth lumbar vertebrae, in 12 instances between the third and fourth lumbar vertebrae, in 4 instances between the second and third lumbar vertebrae, in 2 instances between the first and second lumbar vertebrae, and in 1 specimen between the twelfth thoracic and first lumbar vertebrae (Fig. 2, *a* and *b;* Fig. 3, *c* and *d;* Fig. 4; Fig. 5, *a* and *b;* Fig. 6 and 7). Localized (unilateral) posterior disc protrusion, with evidence of degenerative disease of the remainder of the intervertebral disc, was observed in 5 instances (once each between the fifth lumbar and first sacral, the fourth and fifth lumbar, the third and fourth lumbar, and the first and second lumbar vertebrae, and twice between the second and third lumbar vertebrae) (Fig. 8 and 9).

2. Degeneration of the intervertebral disc with subsequent narrowing of the intervertebral space may be associated with a settling of the upper vertebral body downward and backward on the vertebral body below, so that the posteroinferior border of the upper vertebral body and the overlying disc material projects posteriorly into the neural canal. This apparent "posterior displacement of the vertebral body" is not infrequently exaggerated by bony proliferation of this posteroinferior margin. In my material, the posterior margin of the fifth lumbar vertebra extended posterior to that of the sacrum a distance of 2/16 inch or more in 11 specimens (Fig. 3, *a* and *b;* Fig. 5, *c* and *d;* Fig. 6 and 7).

3. Apparent forward bulging of the ligamentum flavum, often constricting the intervertebral foramen, has been demonstrated in some specimens to be due to forward projection of the ligamentum flavum, often of normal thickness, by marginal bony proliferation of the underlying facets of the apophyseal joint. In my material, this lesion was encountered between the fifth lumbar and first sacral vertebrae, in 4 specimens bilaterally and in 1 specimen unilaterally and on the right, and between the fourth and fifth lumbar vertebrae in 1 specimen bilaterally, and in 2 specimens unilaterally and on the right (Fig. 3, *c* and *d;* and Fig. 7).

That these lesions may be asymptomatic, even though they encroach upon the lumen of the neural canal, may be explained in the lumbar region by the fact that the vertebral canal is large in this region and that the cauda equina is displaced within a wide range before pressure

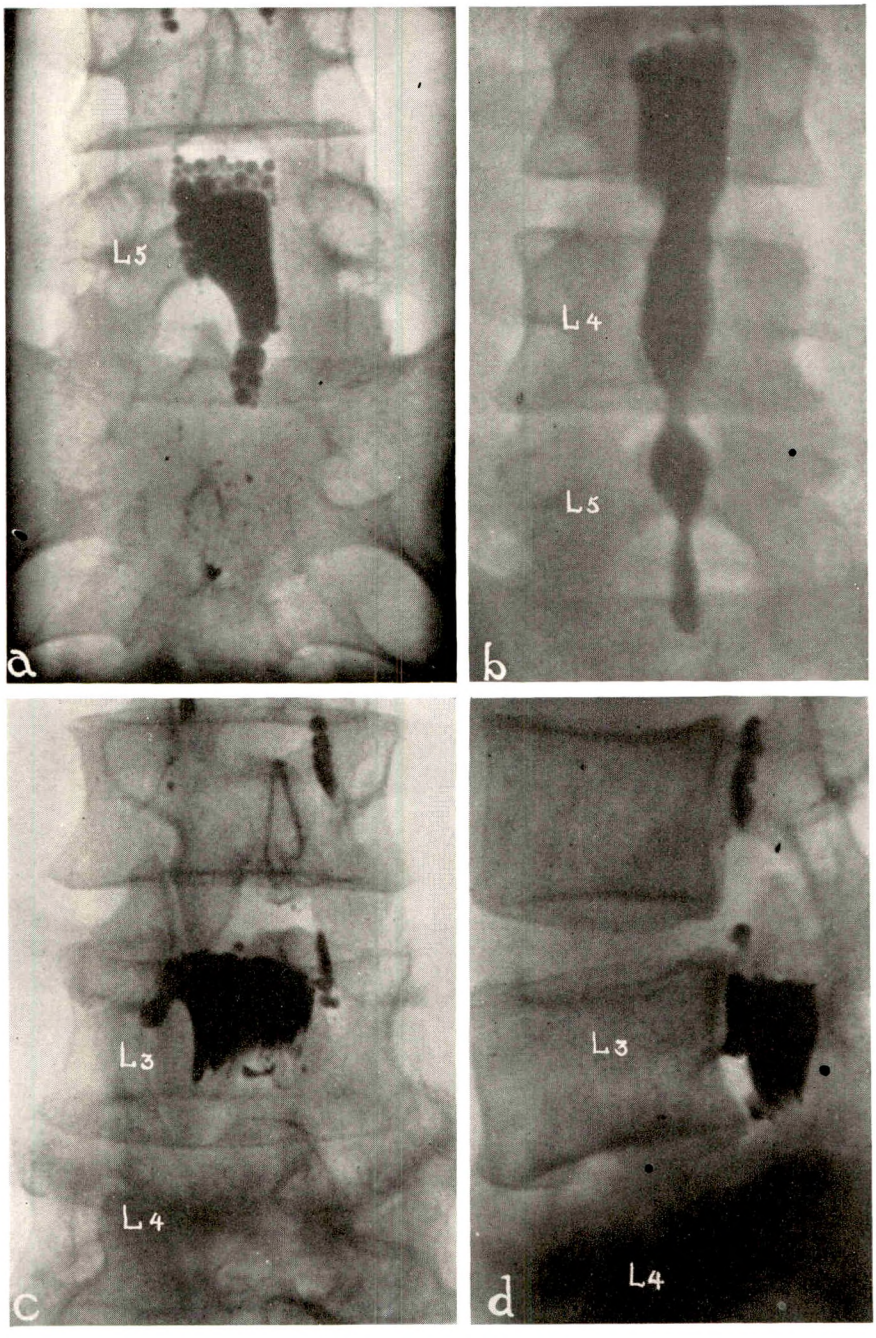


FIG. 1. Myelograms in (*a*) a twenty-seven year old female, (*b*) a thirty-nine year old female, and (*c* and *d*) a forty-four year old male, showing defects in the column of lipiodol which were constant. Each case presented a unilateral sciatic syndrome and a clinical picture consistent with a diagnosis of an intraspinal lesion, possibly a posterior protrusion of the intervertebral disc. Laminectomy, performed at the proper level in each instance, failed to disclose any intraspinal lesion. There was no demonstrable involvement of the intervertebral disc, and the ligamentum flavum was of normal thickness, with a normal histologic structure. Complete recovery, for no apparent reason, followed the laminectomy in case (*a*), partial recovery occurred in case (*b*), and there was no postoperative improvement in case (*c–d*).

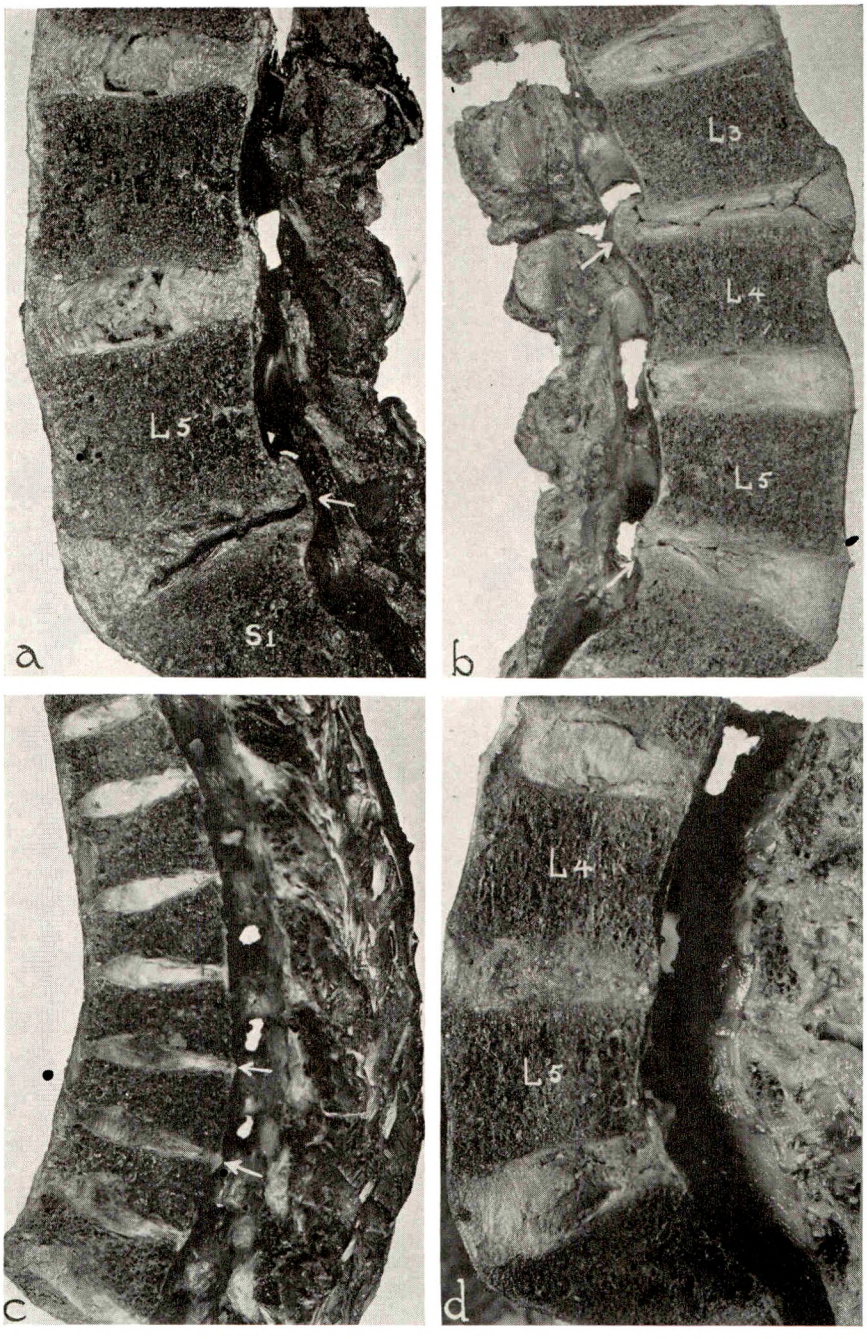


Fig. 2. Midsagittal sections of the lumbar spine in (*a*), (*b*) and (*d*), and of the lower thoracic spine in (*c*). Degenerative disease of the intervertebral disc with posterior protrusion into the spinal canal and encroachment of the corresponding intervertebral foramen is demonstrated in (*a*) between the fifth lumbar and first sacral vertebrae, and in (*b*) between the fifth lumbar and first sacral and between the third and fourth lumbar vertebrae. In (*c*) there is degenerative disease of many of the intervertebral discs of the lower thoracic segments, with protrusion of disc material into the spongiosa of the adjacent vertebral bodies. The arrows in this illustration indicate two slight posterior protrusions of disc substance. In (*d*) the intervertebral disc between the fourth and fifth lumbar vertebrae has undergone advanced degenerative changes —narrowing, dehydration, fragmentation, and "brown degeneration," but there is no demonstrable posterior protrusion of disc material.

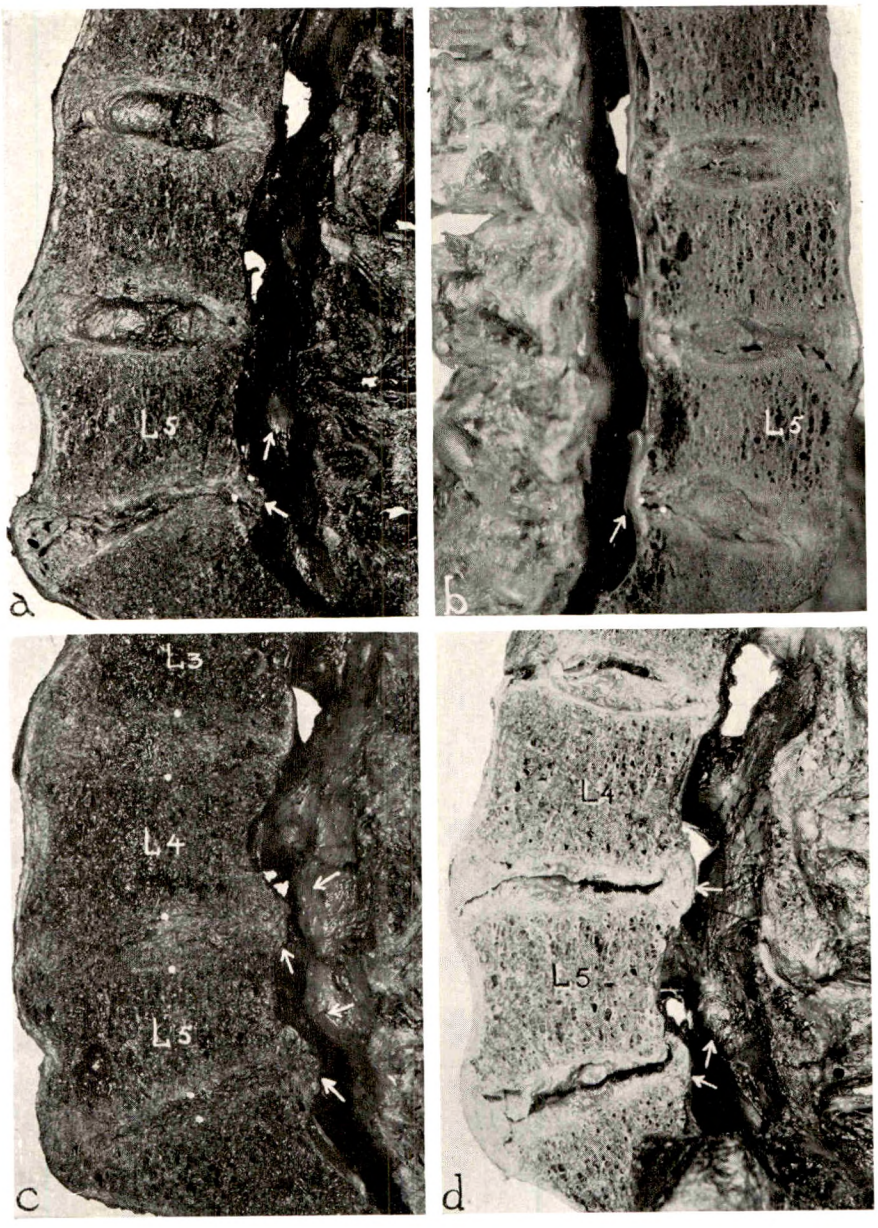


FIG. 3. Midsagittal sections of the lumbar spine. In (*a*) and (*b*) the posteroinferior margin of the fifth lumbar vertebra lies dorsal to the posterosuperior border of the sacrum, and, with the overlying disc substance, projects into the lumen of the spinal canal. In (*c*) and (*d*) there is advanced degenerative disease of all of the intervertebral discs with posterior protrusions at the level of the discs between the fourth and fifth lumbar and between the fifth lumbar and first sacral vertebrae. The forward bulging of the ligamentum flavum at these levels was shown to be due to hypertrophy of the underlying articular facets.

effects are produced, its components being fixed only at their origin and at their exit from the dural canal. This is well demonstrated by the absence of objective neurologic findings in most cases of advanced spondylolisthesis, in which lesion there is a marked encroachment on the neural canal. An intraspinal lesion in the cervical and thoracic regions, on the contrary, cannot assume much size without compressing some conductive nerve pathway and expressing itself clinically. In the cadaver

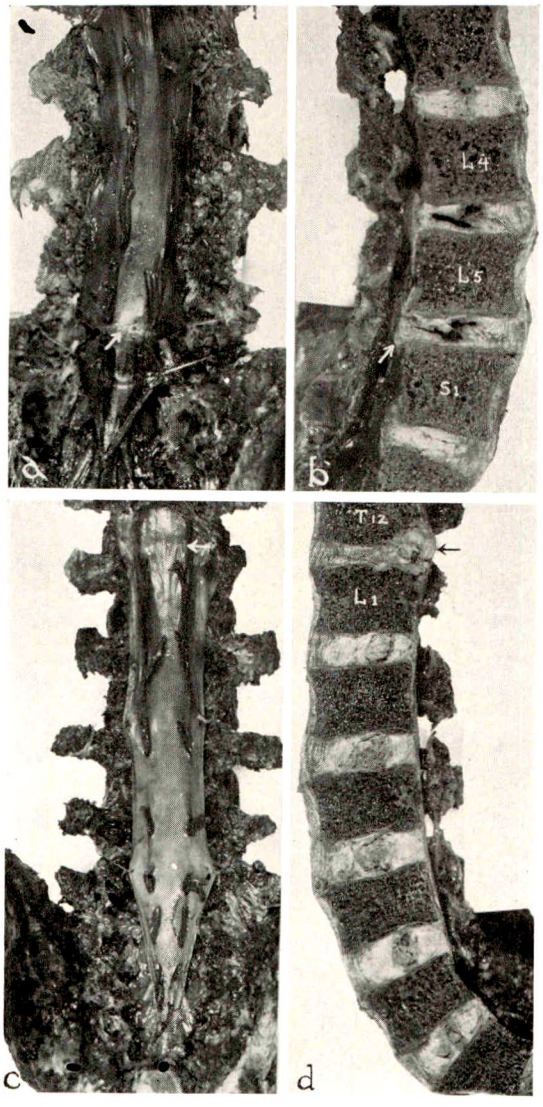


FIG. 4. In (*a*) and (*c*) the dural sacs of two lumbar spines have been opened posteriorly, following complete laminectomy; (*b*) and (*d*) are corresponding midsagittal sections.

The posterior protrusions of disc substance which are associated with degenerative disease of the disc between the fifth lumbar and first sacral vertebrae in (*b*) and between the twelfth thoracic and first lumbar vertebrae in (*d*) encroach at these levels on the lumen of the dural sac in (*a*) and in (*c*), respectively.

material of Duncan,[8] while the nerve roots and the spinal cord sometimes showed gross evidence of compression and deformity as a result of these degenerative lesions, no specific microscopic nerve changes were directly attributable to these lesions, and the changes were insufficient to account for functional disturbance.

There is a growing appreciation that the localized type of posterior protrusion of the intervertebral disc, to which a specific clinical picture is attributed and in which relief is often so spectacular following excision of the compressing lesion, not infrequently originates from the effects of trauma, single or repeated, *on an intervertebral disc that already demonstrates some degree of degeneration* (Saunders and Inman,[18] Donohue[6]). No consistent relation has been observed between changes such as narrowing of the intervertebral disc or marginal bony proliferation (lesions that manifest themselves on the ordinary roentgenogram of the spine) and the occurrence of posterior disc protrusions (Fig. 2, *d;* Fig. 10, *a* to *d;* Fig. 12, *c* and *d*). The majority of disc protrusions have been reported in patients in the fourth and fifth decades of life and involve the lower lumbar vertebrae, when and where degenerative phenomena are most common in the spine. The occurrence of multiple disc lesions in the same individual (Love and Walsh[14]) may be taken as evidence of the relation of this lesion to degenerative disease of the intervertebral disc.

MYELOGRAPHY IN THE DIAGNOSIS OF POSTERIOR PROTRUSION OF THE INTERVERTEBRAL DISC IN THE LUMBAR SPINE, AND THE DIAGNOSTIC LIMITATIONS OF THIS PROCEDURE

The anatomic features of the normal and abnormal myelograms of this lesion have been defined by Hampton and Robinson,[12] and Robinson,[16] and they have been corroborated in my anatomic material. The advantages and disadvantages of the various types of contrast media and, in the instance of iodized oil, the quantity of medium to be employed, are controversial subjects that will not be discussed in this presentation.

The Normal Myelogram. The spinal cord terminates in the conus medullaris at the

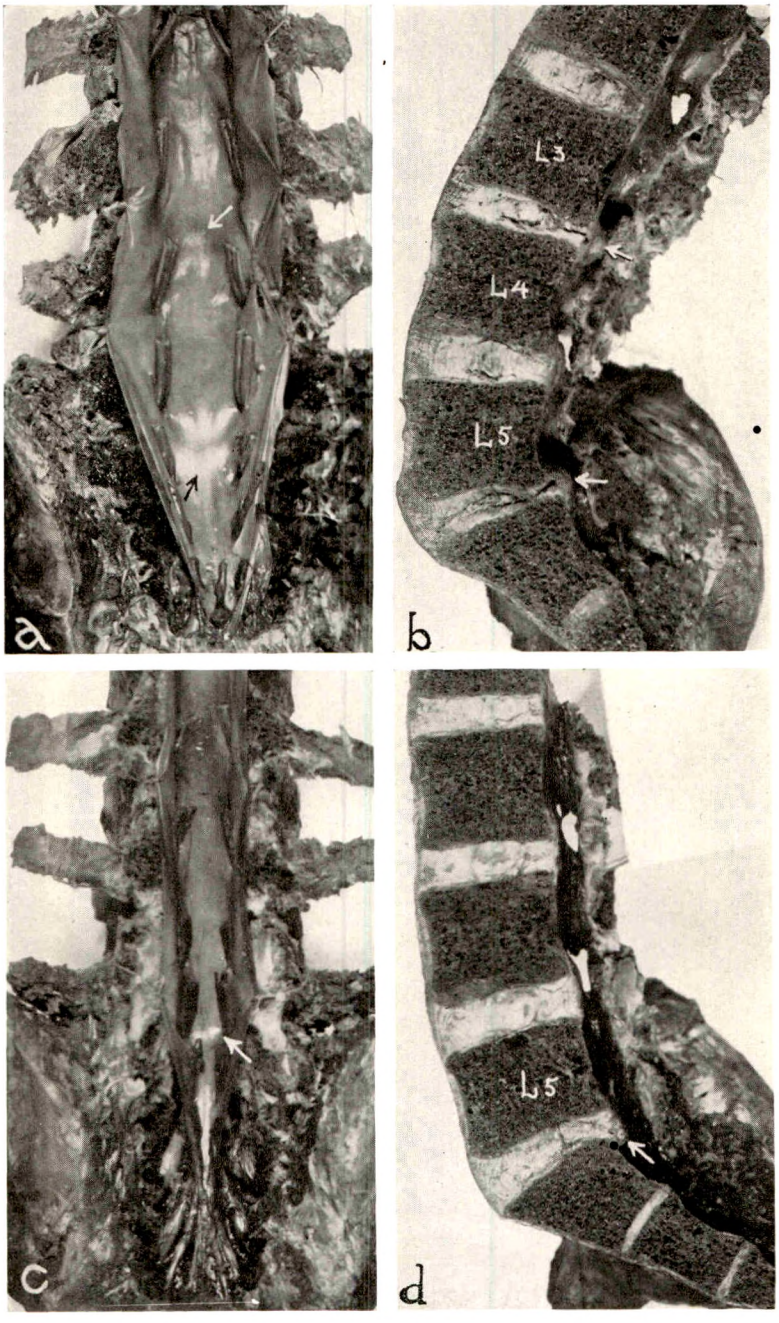


FIG. 5. In (*a*) and (*c*) the dural sacs of two lumbar spines have been opened posteriorly, following complete laminectomy; (*b*) and (*d*) are corresponding midsagittal sections.

The posterior protrusions of disc substance which are associated with degenerative disease of the discs between the third and fourth lumbar and between the fifth lumbar and first sacral vertebrae in (*b*), and between the fifth lumbar and first sacral vertebrae in (*d*), encroach at these levels on the lumen of the dural sac in (*a*) and in (*c*), respectively. The extradural defect in (*d*) is exaggerated by the downward and posterior displacement of the fifth lumbar body, so that its posterior border lies dorsal to that of the sacrum.

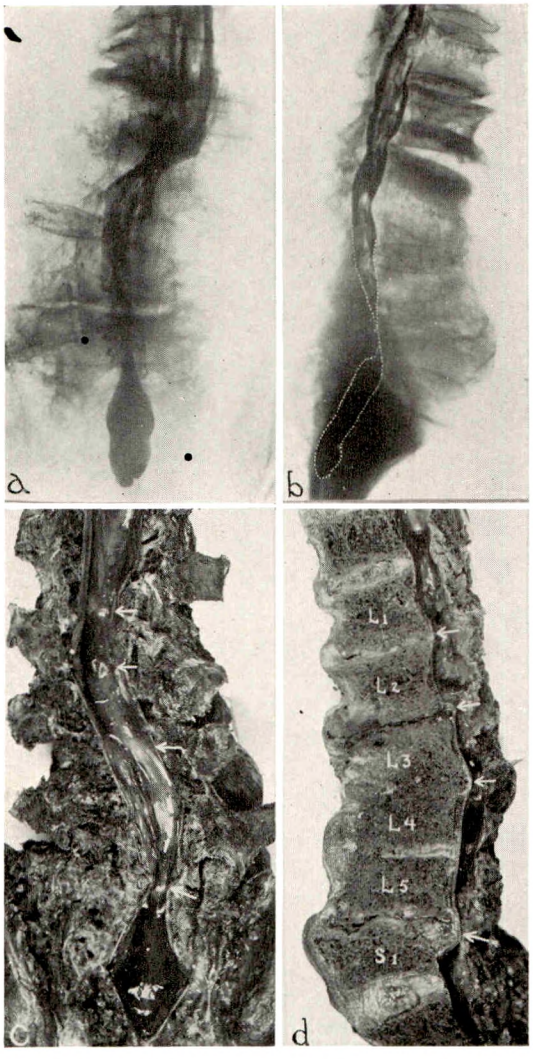


FIG. 6. (*a*) posteroanterior and (*b*) lateral lipiodol laminagrams, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal view of a lumbar spine with advanced degenerative disease of the vertebrae and the intervertebral discs. Attention is called specifically to the encroachments on the spinal canal, observed in all of these views, at the levels of all of the lumbar intervertebral discs, except that between the fourth and fifth lumbar vertebrae. The constricting lesion at the level of the lumbosacral disc is due, anteriorly, to posterior bulge of disc substance and the projecting posteroinferior margin of the fifth lumbar body, and, laterally, to proliferative changes in the zygapophyseal joints.

top of the second lumbar vertebra, and from its periphery arise the sensory and motor divisions of the lumbar and sacral nerve roots. The opaque medium, utilized in contrast myelography, is injected into the subarachnoid space, and is delimited externally by the arachnoid membrane and internally by the pia mater. Where a nerve root leaves the dural sac, it creates an out-pocketing or arachnoid pouch as it carries with it a portion of the three meningeal layers as its sheath. Due to the intimate contact of the nerve root to the lateral wall of the dural sac, some part of the root, rather than the wall of the lumbar sac, forms the lateral outline of the myelogram. The lateral, triangular-shaped projections correspond to the lower portions of the arachnoid out-pocketings that do not contain nerve root and therefore fill with contrast medium. The upper portion of these pouches fills only to a variable degree, but these "streaks" serve to delineate the nerve root. The apices of the triangular shadows demarcate approximately the termination of the dural sheaths of the nerve roots. Hampton and Robinson[12] and Robinson[16] have shown that, if the nerve outline is not distinct, this may be determined by utilizing the constant relationship that the lateral wall of the dural sac and the sheathed portion of the nerve root bear to the inner border of the bony pedicle (Fig. 11).

The Abnormal Myelogram. A defect in the outline of the contrast medium, to be of significance, must be constant and should be ascertained on more than one view. The size of a constant defect in the column of contrast medium does not predict the true size of the underlying pathologic lesion. Much of the lesion may be beyond the confines of the neural canal and it will therefore create only a minimal defect. On the other hand, the size of the defect may become exaggerated by changes in the nerve roots.

Since the majority of localized posterior disc protrusions present to one side of the midline, the classic defect on the myelogram will be a unilateral indentation which overlies, entirely or in part, the corresponding intervertebral space. The lesion, since it is anterior, will be visualized best in the prone and prone-oblique views. In the lateral view, this unilateral defect may be

overshadowed and obscured. Small midline protrusions may produce so minimal a central defect that they may be detected only by the critical study of the moving column of contrast medium; a large midline lesion may obstruct the column partially or completely. If the lesion extends across the entire width of the disc, there will be produced a bilateral defect on the posteroanterior view. A similar, symmetrical defect with a clear central channel will be produced by bilateral hypertrophy of the ligamentum flavum, and will also be produced by the degenerative type of disc lesion with posterior bulging of disc material and underlying hypertrophied bone, a lesion previously referred to (Fig. 2, 3, 4, 5, 6, 7 and 9). The basis for this "hourglass" type of defect is the triangular conformation of the neural canal in the lower lumbar spine. A unilateral defect, with its upper and lower limits sharply defined, may be produced by unilateral hypertrophy of the ligamentum flavum. It might also be produced by anterior bulging of a ligamentum flavum of normal thickness and overlying a hypertrophied articular facet (Fig. 3, *c* and *d;* and Fig. 7). In these instances the lateral view of the column of contrast medium will demonstrate an anterior or posterior indentation, or both, since disc and ligamentum flavum lesions may coexist. The abnormal myelogram may be further modified by evidence of nerve root displacement. In addition, evidence of edema of the nerve root may express itself by the additional indentation of the main column of contrast medium or by obliteration of the shadow of its nerve sheath and dural outpouching. Asymmetry of these axillary pouches may occur normally, and this defect, when constant, as with other constant defects in the myelogram, must be evaluated in the light of the clinical findings.

Possible Factors in Negative Myelography in the Presence of Positive Operative Findings.

1. Normal Anatomic Factors. These have been emphasized by Hampton and Robinson[12] and Robinson.[16]

a. The majority of posterior disc protrusions have been observed between the fourth and fifth lumbar vertebrae and between the fifth lumbar and first sacral vertebrae. Since the fifth lumbar nerve is intradural as it crosses the fourth lumbar disc, a posterior protrusion of this disc cannot compress this root without creating a defect in the outline of the lumbar sac. This root leaves the canal above the lumbosacral (fifth lumbar) disc, and it will not be affected by a posterior lesion of the latter disc. The first sacral nerve root acquires its sheath between the upper and lower borders of the lumbosacral disc and it is therefore not entirely within the lumbar sac in its course across this disc. A posterior disc protrusion at this level, therefore, may compress the first sacral root, or, if large enough, the other, more medially placed sacral roots, and still produce a minimal defect or no defect in the column of opaque medium (Fig. 11).

b. The arachnoid outpouchings are poorly defined at the lower end of the neural canal, since the nerve roots in this area descend almost vertically. Changes in their outline by pressure of an extradural lesion, therefore, cannot be easily determined (Fig. 11).

c. Another feature which makes the evaluation of a myelogram at or below the level of the lumbosacral disc more difficult is the normal lumbosacral angulation and sacral tilt, which causes the lower portion of the dural sac to be visualized "on-end" in the prone or supine positions (Fig. 11).

2. Anatomic Variations of the Cul-de-Sac. Camp[3,4] has called attention to two anomalies in this region that have accounted for errors of interpretation in some of his cases with negative iodized oil myelograms and positive surgical findings. In one type, the cul-de-sac terminated at about the level of the second sacral segment, but it was considerably narrower than normal below the level of the fourth lumbar intervertebral space. Although no instance of this anomaly was demonstrated in my cadaver material, I have observed the opposite variation, probably also de-

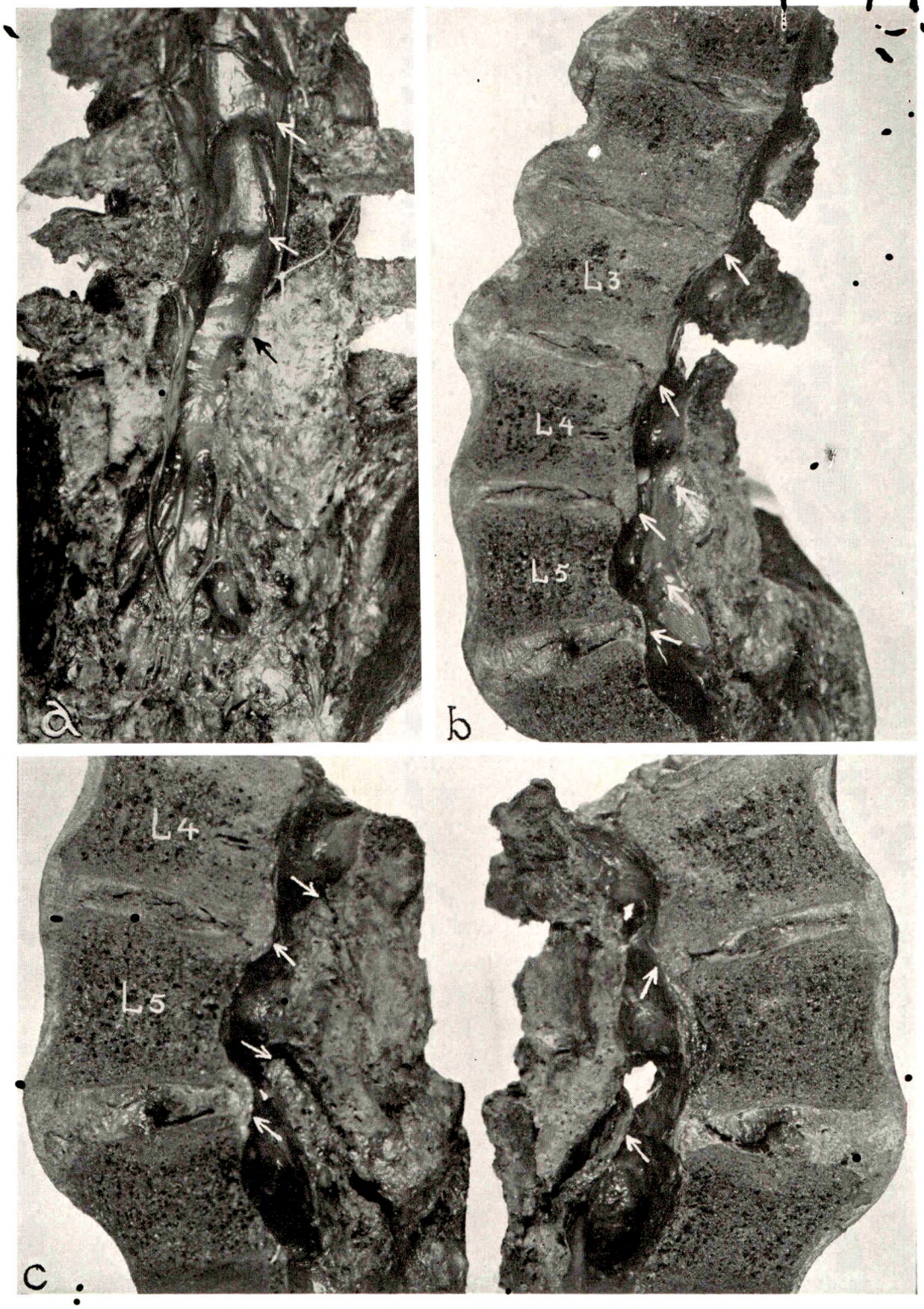


Fig. 7. (*a*) intraspinal view after opening the dural sac posteriorly, and (*b*) right midsagittal section of a lumbar spine with advanced degenerative disease of the vertebrae and the intervertebral discs. In (*c*) the

velopmental in origin, of an enormous dilatation of the caudal sac (Fig. 12). In this specimen, 5 cc. of lipiodol served to fill only the most terminal portion of the sac. In the other variation noted by Camp, the cul-de-sac terminated more proximal than normal, even above the level of the lumbosacral interspace. While shortening of the caudal sac may be simulated on the anteroposterior myelogram, due to the lumbosacral angulation and sacral tilt (see Fig. 1, *c*), the termination at a normal level in this instance will be demonstrated by the lateral myelogram.

The caudal canal was observed, by the writer, to terminate in 58 consecutive cadavers at the following levels:

Just distal to the lumbosacral disc and opposite the 1st sacral body	2
Opposite the intervertebral disc between the 1st and 2nd sacral segments	24
Opposite the 2nd sacral segment	30
Opposite the level between the 2nd and 3rd sacral segments	2

In the presence of any of these three anomalies of the cul-de-sac, the presence of an extradural lesion, in the region of the terminal portion of the caudal canal, could not be accurately ascertained by contrast meylography.

Possible Factors in Positive Myelography in the Presence of Negative Operative Findings. Although explanations for these errors of interpretation, such as that the myelographic defect might have been due to a thickened ligamentum flavum which was removed during laminectomy, or that the operator had failed to locate properly the anatomical site of the suspected disc lesion, are to be considered, these factors were excluded in my cases (Fig. 1). That the defect might have been caused by a "self-reducing" posterior disc protrusion (if such a mechanism occurs) is not acceptable to me in my cases, in view of the fact that no defect was demonstrable, grossly, on inspection of the supposedly involved intervertebral disc, and that the myelographic evidence of a constant defect had been recorded in a position identical to that assumed by the patient during operation, that is, lying upon the abdomen.

Smooth, often multiple, hour-glass contractions, unless constant, are to be evaluated critically, since such phenomena may occur normally as a result of "stringing out" of the contrast medium, when iodized oil is employed (Hampton and Robinson,[12] Robinson[16]). The appearance of multiple protrusions during roentgenoscopic examination with iodized oil is often no more than an exaggeration of the normal prominence of the lumbar intervertebral discs (Bradford and Spurling[2]). Irregular, slow-moving columns will be produced by the extradural or subdural (extra-arachnoid) introduction of this contrast medium. These artefacts, which may lead to faulty interpretation, are not constant on repeated examinations. Such misplacements of iodized oil may follow reduction of spinal fluid pressure, as by lumbar puncture or air spinography (Hamby[10]).

It has been demonstrated in my material that extradural lesions may be produced by degenerative disease involving the intervertebral disc (posterior bulging of the entire disc with underlying hypertrophy of the adjacent bony margins) and the articular facets of the apophyseal joints (bony proliferation of the margins with forward bulging of the overlying ligamentum flavum), and that these lesions may produce defects in the subarachnoid column of contrast medium (Fig. 6). Hampton and Robinson,[12] and Robinson[16] observed that

right and left sagittal sections of the lower lumbar segments and upper sacrum are demonstrated. There are encroachments, anteriorly, on the spinal canal at the level of all of the intervertebral discs, due to posterior bulging of disc substance and posterior marginal proliferation of the adjacent vertebral bodies. The bulges in the posterior portion of the spinal canal, in the region of the ligamentum flavum between the fourth and fifth lumbar and between the fifth lumbar and first sacral vertebrae, which are evident in (*b*), are shown in (*c*) to be due to marginal proliferation of the underlying facets.

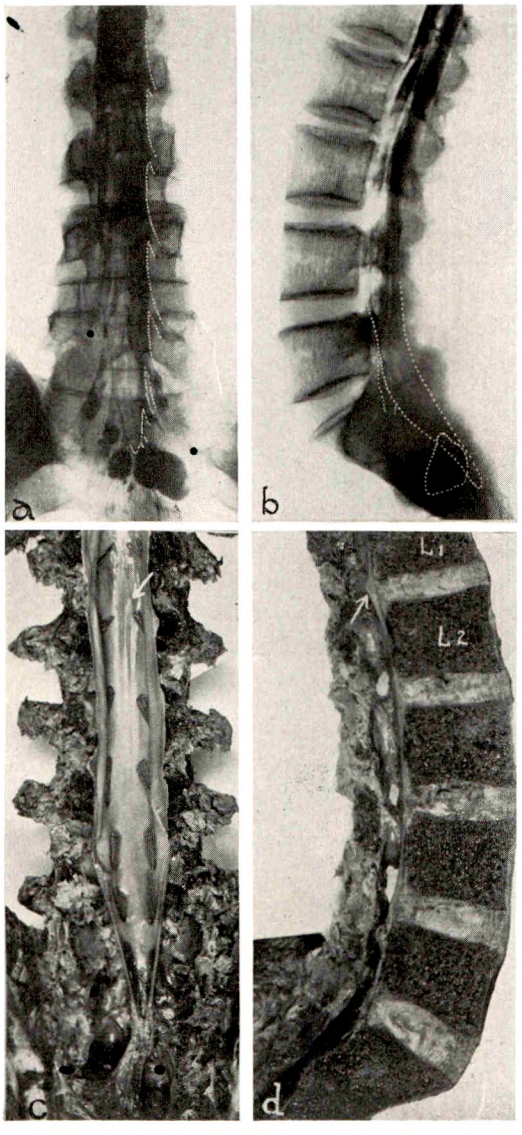


FIG. 8. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal view of a lumbar spine. No defects in the column of contrast medium are evident in (*a*) and (*b*). In (*c*) there is a central localized projection at the level of the intervertebral disc between the first and second lumbar vertebrae, due, as is shown in (*d*), to posterior protrusion of disc substance. An unusual dilatation of the dural sheaths of some of the terminal roots of the cauda equina is evident in (*a*) and (*c*), which, in the absence of any pathologic process in this region, were interpreted as being developmental in origin.

sharply defined, symmetrical defects on the myelogram at a disc level were sometimes caused by "posterior hypertrophy" of the intervertebral disc as a whole.

A small central posterior disc protrusion may be obscured in all views of the myelographic study by overlying contrast medium (Fig. 8). The question properly

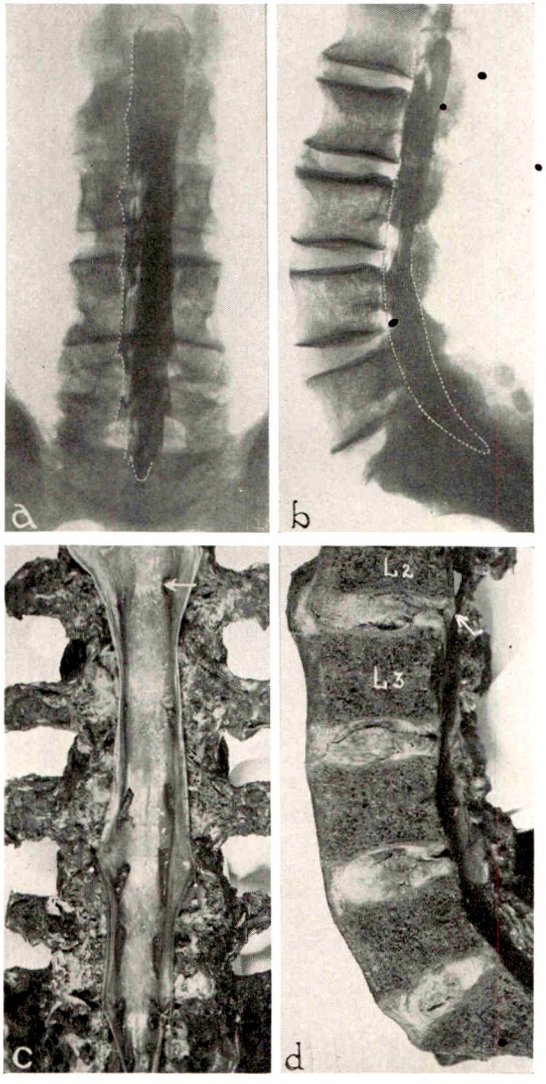


FIG. 9. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view after opening the dural sac posteriorly, and (*d*) midsagittal section of a lumbar spine. No defects are observed in the column of contrast medium in (*a*) and (*b*). In (*c*) and (*d*) there is evident a posterior bulge of the entire width of the disc between the second and third lumbar vertebrae, associated with degeneration of the remainder of the intervertebral disc and marked bony proliferation of the adjacent vertebral bodies.

arises whether such a minimal lesion would be productive of sufficient symptoms and signs to warrant exploration. Dandy[5] has suggested that negative explorations may

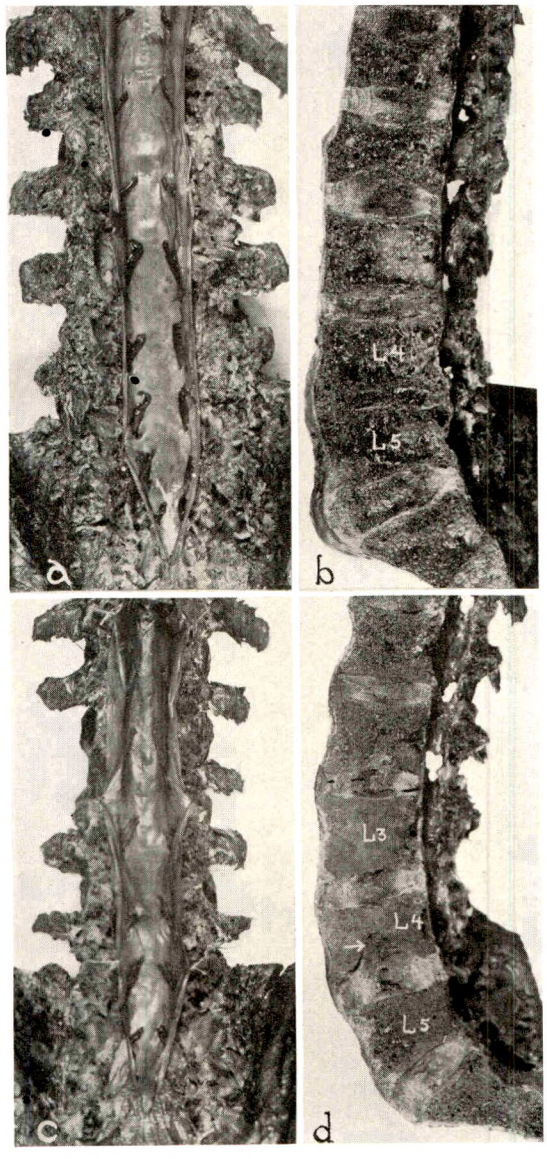


FIG. 10. (*a*) and (*c*) are intraspinal views after opening the dural sac posteriorly, and (*b*) and (*d*) are midsagittal sections of two lumbar spines with advanced degenerative disease of the vertebrae and the intervertebral discs. In (*d*) there is a marked protrusion of the disc between the fourth and fifth lumbar vertebrae into the spongiosa of the fourth lumbar body. There are no distinct encroachments on the spinal canal, despite the presence of advanced degenerative disease in both specimens.

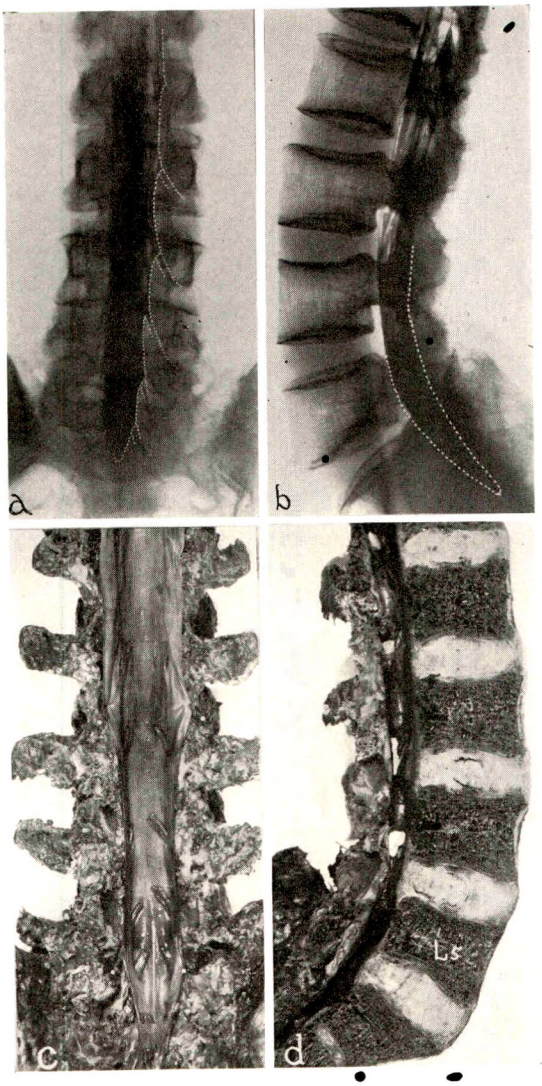


FIG. 11. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view, and (*d*) midsagittal section of a normal lumbar spine.

be due to "concealed ruptured intervertebral disks," in which the posterior protrusions are so slight that they are disclosed at operation only after careful search. It is difficult for me to understand how such lesions which such slight posterior protrusion, especially when these are centrally placed, would produce the symptom-complex of an extradural lesion sufficient to warrant laminectomy. It is my opinion, based on Dandy's description, that the histopathologic features of this lesion are

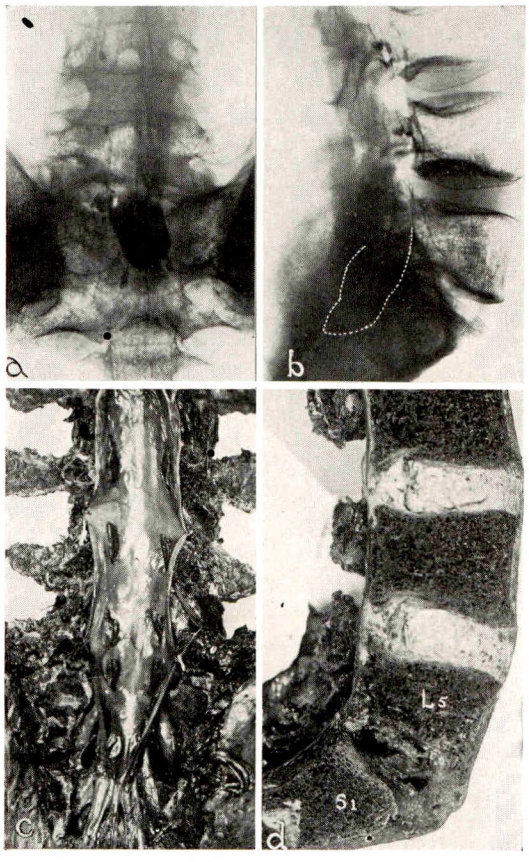


FIG. 12. (*a*) posteroanterior and (*b*) lateral lipiodol myelograms, (*c*) intraspinal view, and (*d*) midsagittal section of a lumbar spine, showing an enormous dilatation of the caudal sac, and advanced degenerative disease of the lumbosacral disc, without posterior protrusion of disc substance.

those characteristic of degenerative disease of the intervertebral disc—fibrillation, dehydration, softening, and "brown degeneration" (Horwitz[13]) (Fig. 2, *d;* Fig. 10, *b* and *d;* Fig. 12, *d*). Degenerative disease of the intervertebral disc has been considered a cause of back pain by the orthopedic surgeon, who has treated this lesion by external or internal fixation.

SUMMARY AND CONCLUSIONS

Despite considerable work in this direction, there is need for clarification of a number of problems relating to the diagnosis and treatment of lesions of the intervertebral disc with posterior protrusion into the spinal canal and/or the intervertebral foramen, and to an accurate interpretation of the exact nature of this lesion. The diagnostic criteria are often equivocal. In this respect, the material in this investigation has been evaluated in an effort to illustrate and explain some of the discrepancies in contrast myelography. Most investigators rely on myelography in the diagnosis of this lesion, although there are some who feel that the clinical findings are sufficient for the diagnosis and the localization of this lesion in a high percentage of cases. The interrelation of posterior disc protrusion and other potential factors in the causation of low back pain and the sciatic syndrome, such as degenerative disease of the intervertebral disc, of the vertebrae, and of the zygapophyseal articulations, requires clearer definition. The determination of the best surgical procedure for the treatment of posterior protrusion of the intervertebral disc must await an evaluation of sufficient clinical material, observed over a number of years. The wisdom, at present, of a conservative attitude, is reflected in the conclusions of Bradford and Spurling[2] in their recent monograph on this subject: "Although the presence of a spinal neoplasm is unequivocally an indication for surgical removal where possible, the presence of posterior herniation of the nucleus pulposus is not an indication for surgical removal unless it has produced incapacitating radicular symptoms."

REFERENCES

1. BARR, J. S., and MIXTER, W. J. Sciatic pain in low-back derangements: its incidence, significance, and treatment; symposium; posterior protrusion of lumbar intervertebral discs. *J. Bone & Joint Surg.*, 1941, *23*, 444–456.
2. BRADFORD, F. K., and SPURLING, R. G. The Intervertebral Disc with Special Reference to Rupture of the Annulus Fibrosus with Herniation of the Nucleus Pulposus. Charles C Thomas, Springfield, Ill., 1941.
3. CAMP, J. D. Roentgenologic diagnosis of intraspinal protrusion of intervertebral disks by means of radiopaque oil. *J. Am. M. Ass.*, 1939, *113*, 2024–2029.
4. CAMP, J. D. Contrast myelography. *Med. Clin. North America*, 1941, *25*, 1067–1102.
5. DANDY, W. E. Concealed ruptured intervertebral

bral disk; plea for elimination of contrast mediums in diagnosis. *J. Am. M. Ass.*, 1941, *117*, 821–823.

6. Donohue, W. L. Pathology of intervertebral disc. *Am. J. M. Sc.*, 1939, *198*, 419–437.
7. Duncan, D., Seybold, W. D., Hotchkiss, W. S., and Kahler, G. E. Preliminary study of intervertebral disc protrusions and associated abnormalities in a series of dissecting room subjects. *Bull. John Sealy Hosp. & School of Medicine (Univ. of Texas)*, 1940, *2*, 57–64.
8. Duncan, D. Report of some pathological changes noted during routine examination of spinal cords from the dissecting room. *Bull. John Sealy Hosp. & School of Medicine (Univ. of Texas)*, 1940, *2*, 64–75.
9. Farrell, B. P., and MacCracken, W. B. Sciatic pain in low-back derangements; its incidence, significance, and treatment; symposium; spine fusion for protruding intervertebral discs. *J. Bone & Joint Surg.*, 1941, *23*, 457–460.
10. Hamby, W. B. Misplaced spinal lipiodol; analysis of 104 lipiodol spinograms. *Radiology*, 1941, *37*, 343–346.
11. Hampton, A. O. Iodized oil myelography; use in diagnosis of rupture of intervertebral disk into the spinal canal. *Arch. Surg.*, 1940, *40*, 444–453.
12. Hampton, A. O., and Robinson, J. M. Roentgenographic demonstration of rupture of intervertebral disc into spinal canal after injection of lipiodol. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 782–803.
13. Horwitz, T. Lesions of intervertebral disk and ligamentum flavum of lumbar vertebrae; anatomic study of 75 human cadavers. *Surgery*, 1939, *6*, 410–425.
14. Love, J. G., and Walsh, M. N. Protruded intervertebral disks; report of 100 cases in which operation was performed. *J. Am. M. Ass.*, 1938, *111*, 396–400.
15. Love, J. G., and Walsh, M. N. Intraspinal protrusion of intervertebral disks. *Arch. Surg.*, 1940, *40*, 454–484.
16. Robinson, J. M. Retropulsion of lumbar intervertebral discs as cause of low back pain with unilateral "sciatic" radiation; roentgenologic diagnosis, with special reference to iodolography. *Am. J. Surg.*, 1940, *49*, 71–88.
17. Saunders, J. B. de C. M., and Inman, V. T. The intervertebral disc; critical and collective review. *Internat. Abst. Surg. (Surg., Gynec. & Obst.)*, 1939, *69*, 14–29.
18. Saunders, J. B. de C. M., and Inman, V. T. Pathology of intervertebral disk. *Arch. Surg.*, 1940, *40*, 389–416.
19. Semmes, R. E. Diagnosis of ruptured intervertebral disc without contrast myelography and comment upon recent experiences with modified hemilaminectomy for their removal. *Yale J. Biol. & Med.*, 1939, *11*, 433–435.
20. Spurling, R. G., and Bradford, F. K. Neurologic aspects of herniated nucleus pulposus at fourth and fifth lumbar interspaces. *J. Am. M. Ass.*, 1939, *113*, 2019–2022.
21. Spurling, R. G., and Grantham, E. G. Neurologic picture of herniations of nucleus pulposus in lower part of the lumbar region. *Arch. Surg.*, 1940, *40*, 375–388.

INTRASPINAL THOROTRAST*

By WILLIAM A. NOSIK, M.D.
Cleveland Clinic
CLEVELAND, OHIO

THE high incidence of protruded intervertebral discs in patients with sciatic pain has stimulated the interest of the orthopedist, the neurological surgeon and the roentgenologist. The accuracy of diagnosis of the protruded intervertebral disc is very high when symptoms and signs are definite. However, there is a considerable number of patients in whom the clinical signs are suggestive of the condition but not sufficiently clear to justify an exploratory operation. It is extremely desirable to have accurate diagnostic information regarding the nature and exact location of the lesion. Although a high degree of accuracy can be obtained in the neurologic diagnosis of intraspinal disease, in some cases confirmatory evidence is needed. For this reason, roentgenologic study of the spinal canal is made with some type of contrast medium. Commonly used media for this purpose are lipiodol, air and, more recently, thorotrast. The choice of a contrast medium, however, should depend upon the amount of information it gives regarding the contours of the subarachnoid space. This agent should also meet the requirements of the ideal intraspinal contrast medium, as set forth by Coe, Otell and Hedley,[1] namely: (1) it should be nontoxic, (2) it should be of sufficient atomic weight to cast a clear-cut shadow, (3) it should be nonirritating, (4) it should be miscible with cerebrospinal fluid, and (5) it should be readily eliminated.

Thorotrast was used first for encephalography by Radovici and Meller[10,11] of France, by Wustmann,[14] and by Löhr and Jacobi[5,6] of Germany in 1932. In 1936 Freeman and his associates,[3,12] and later Twining and Rowbotham[13] recommended its use in ventriculography.

It occurred to me that it might be possible to utilize the desirable properties of thorotrast (its heavy atomic weight, its high specific gravity, and its miscibility with the cerebrospinal fluid) in the visualization of the spinal subarachnoid space, and to eliminate it from the canal by a forced spinal drainage.[4] After a series of animal experiments, with Mortensen,[9] the practicability of this plan was established. The first intraspinal use of thorotrast and its subsequent removal by forced drainage was done clinically by me in 1937.[8] The resulting films showed such promise of being of diagnostic value that further study was made, with the final evolution of the following technique:

Preparation:

1. The patient is prepared for the laminectomy which may follow the myelogram.
2. A sedative is given one hour before myelography.
3 The patient is taken to the roentgen room in a wheel chair.

Myelogram:

1 The patient is put on the tilted roentgen table with the head elevated from 12 to 15 degrees above the horizontal plane.
2. Lumbar puncture is done between the first and second, or second and third lumbar vertebrae; fluid may be taken for analysis if desired, and 10 cc. of thorotrast is injected at an even rate of injection. The needle is then withdrawn.
3. With the patient still in the tilted position, and the head elevated, roentgenoscopy may be done to make certain that the distribution of the medium is correct.
4. Roentgenograms are then made with the patient in the anteroposterior, postero-

* Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1942.

anterior, right and left lateral oblique, and the direct lateral positions. Head elevation is maintained throughout. The machine settings usually used for a 150 pound patient are:

	in.	kv.	ma.	Time
Posteroanterior	30	62	40	5 sec.
Anteroposterior	30	65	40	5 sec.
Oblique	30	65	40	5 sec.
Lateral	30	76	40	10 to 12 sec.

5. Upon completion of the roentgenograms the patient is placed in a wheel chair and is returned to bed, the head of which has been elevated to 25 degrees.

After Myelography:

1. The patient is placed on the unaffected side, with the head elevated, and a low lumbar puncture is made with a large bore needle. The puncture is made above the lesion if the canal is obstructed to a marked degree. The fluid is allowed to drain into a sterile flask.

2. With the spinal needle in place, a venoclysis of 750 cc. of 0.45 per cent saline is begun and allowed to empty in one hour.

3. The spinal drainage needle is withdrawn fifteen minutes after the venoclysis is completed.

4. If a surgical lesion is present the patient is then taken to the operating room.

5. The elevation of the back rest is maintained for twenty-four hours.

The properties of thorium dioxide solution (thorotrast) have been published in a report of the Council on Pharmacy and Chemistry.[2] The composition of this medium is given as a stabilized thorium dioxide solution, 25 per cent by volume (19–20 per cent by weight), in a protective colloid (16–19 per cent by weight) of dextrin preparation. A preservative of 0.15 per cent methyl-p-hydroxy benzoate is added to the solution.

The radioactivity of thorotrast has been summarized in the report of the Council as follows:

Alpha ray—25 cc. of thorotrast is equivalent to maximum of 1 microgram and a minimum of 0.5 microgram of radium (Schlundt).

Beta rays—Too feeble to be of physiological significance (Schlundt).

Gamma rays—25 cc. of thorotrast is equivalent to approximately 0.3 microgram of radium (Flinn) and is too feeble to be of physiological significance (Schlundt).

To consider this material in the light of the ideal intraspinal agent, its toxicity must be regarded first. Since the first injections of this material into the subarachnoid spaces in 1932, there have been enthusiastic reports of the subarachnoid detail which was disclosed. There soon followed much less enthusiastic reports because of severe reactions and even deaths after encephalography with this material. The rise in acidity of the cerebrospinal fluid which often accompanied its usage caused a severe reaction. After considerable experimentation the present thorotrast, an alkaline buffered suspension of thorium dioxide in a protective colloid dextrin, was introduced. A slight acidosis of the cerebrospinal fluid may occasionally still occur in some cases, causing a mild reaction, but generally the material is well tolerated There is no real evidence of its toxicity *per se*, just as there is little evidence to show any real toxicity attributable to the other commonly used mediums.

Retention of thorotrast in the subarachnoid space will result in an aseptic meningeal reaction. However, it is common knowledge that the intraspinal injection of any foreign substance will produce a meningeal reaction proportionate to the irritating effect of the material injected. For this reason, it was felt advisable to remove any contrast medium from the subarachnoid space after it had served its purpose.

The clarity with which the intraspinal structures are visualized with thorotrast is due to the high molecular weight of the particles in suspension. The fact that the heavy thorium dioxide particles are in suspension makes possible the outlining of small fluid-displacing lesions either in the canal or compressing it from outside. In the suggested concentrations the shadow cast

is not heavy enough to mask an underlying lesion, nor is it so faint as to leave the diagnosis uncertain.

The irritating qualities of thorotrast are largely dependent upon the dextrin concentration and the small amount of preservative it contains. The thorium dioxide particles are chemically inactive and contribute to its irritative properties only their presence as foreign bodies of microscopic size. This is unlike the irritating effects of certain iodized solutions and oils which have as their chief source of irritation the liberation of varied amounts of iodine into the surrounding medium. The irritating effects of subarachnoidally placed iodides is well known.

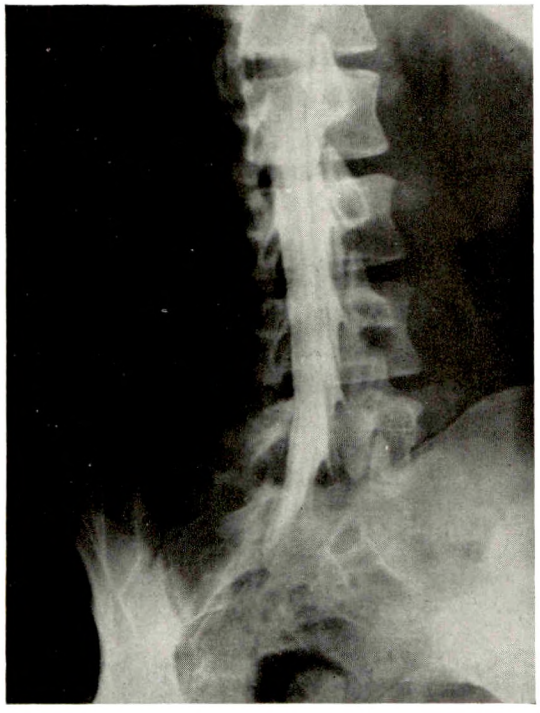


FIG. 1. Normal thorotrast myelogram. The nerve roots and their dural sleeves are demonstrated (oblique view).

Thorotrast possesses the property of miscibility with the cerebrospinal fluid. It is a golden-brown, opalescent fluid of watery consistency whose specific gravity is greater than that of spinal fluid. For this reason the distribution of the medium in the spinal canal can be controlled reasonably well by placing the patient at such angles as to keep the medium at the examination site. It is the property of miscibility with the cerebrospinal fluid that gives thorotrast its chief advantage over other contrast media.

The subarachnoid outline is accurately seen wherever the spinal fluid can penetrate with its contained thorotrast. Consequently, in the area to be examined, the entire width of the spinal canal, the spinal roots in their intraspinal course, together with their dural sleeves are seen in their normal relations (Fig. 1). There is no disturbance of the cerebrospinal fluid dynamics by the withdrawal of a large amount of fluid with a subsequent alteration in the anatomic relations. There is not the problem of a medium with a surface tension so much greater than that of the cerebrospinal fluid that its tendency to assume its smallest form may frustrate the examiner. By breaking up into coarse globules, an oily medium can nullify the usefulness of the examination. Because of the high surface tension of the oily contrast mass, it is not always possible to make the media outline the finer detail of the subarachnoid space. In the larger lesions encroaching upon the spinal canal, the choice of a contrast medium is hardly a serious consideration, since the problem is usually a simple one for the clinician and the roentgenologist. However, it is in that lesion which has caused as yet but little change in the anatomic relations in the spinal canal that thorotrast has its greatest usefulness by its ability to depict with greater accuracy the relative minutiae of the subarachnoid space.

It is highly desirable to remove from the spinal subarachnoid spaces any contrast medium which is not normally absorbed. An oily medium may be partly removed by aspiration under the roentgenoscope or at operation. By virtue of its miscibility with cerebrospinal fluid, from 70 to 95 per cent of an injected thorotrast solution can be recovered by instituting a forced spinal

drainage as previously described after the roentgen studies have been made. It is desirable to remove the thorotrast from the canal because of the low grade radioactivity. In a previous publication,[7] a summary of the radioactivity present in an average case was given. In this case 8 cc. of thorotrast was used and 80 per cent was recovered. It was calculated that the residual of radioactive material dispersed by the reticulo-endothelial cells of the meninges was equivalent in alpha radiation to 0.064 microgram of radium, and in gamma radiation to 0.0256 microgram of radium. It is obvious that this amount is far below any described minimal toxic level, which is a margin of safety considerably greater than many other substances used clinically.

In summarizing the first 100 myelograms in which thorotrast was used at the Cleveland Clinic, Table 1 is presented:

TABLE I

I. No. of cases	100
II. No. of protruded intervertebral discs	62
Miscellaneous lesions	17
Negative myelograms	21
III. Sex	
Males	77
Females	23
IV. Age incidence	
10–20 years	2
21–30 years	12
31–40 years	41
41–50 years	24
51–60 years	19
61–70 years	2
V. Clinical diagnosis made before myelography	
Protruded intervertebral disc	58
Suspected protrusion of intervertebral disc	36
Miscellaneous lesions (mechanical back strain, functional conditions, radiculitis, hip-joint disease)	6
VI. Diagnosis made from myelogram	
Positive for protruded intervertebral disc	66
Positive for other lesions	3
Questionable protrusion of disc	4
Definitely negative myelogram	26
Injected outside canal accidentally	1
VII. Operative findings. Total of 75 operations done; 25 not operated upon	
Protruded intervertebral disc found	62
Miscellaneous lesions	7
Negative explorations	6
VIII. Total of 75 laminectomies done with	
a. 66 (positive or suspected) cases with a diagnosis of protruded intervertebral disc, of which 62 were correct at operation and 4 were incorrect. Of the 4 cases in which the myelogram was suggestive of a lesion and judged erroneous at operation, 2 cases had a prominence of a disc probably not responsible for symptoms, and in 2 there was no pathologic condition.	
b. 9 patients with a negative myelogram were operated upon with only one protrusion of the intervertebral disc found.	
IX. a. In the positive myelograms confirmed by operation the diagnostic accuracy of thorotrast is 93.97 per cent (error of 6.17 per cent).	
b. In the negative myelograms which were explored on clinical grounds alone, the diagnostic accuracy of thorotrast was 89.97 per cent, the error 11.1 per cent.	

The search for the ideal intraspinal contrast medium is not ended. By instituting the technique described here, we have eliminated most of the undesirable features of thorotrast. A medium has not yet been found which will outline every structure within the subarachnoid space, sharply define its every ramification, and then be spontaneously absorbed and eliminated after it has served its purpose.

REFERENCES

1. COE, F. E., OTELL, L. S., and HEDLEY, O. F. Thorotrast encephalography by cisterna puncture; preliminary report of experimental studies. *Med. Ann. Dist. Columbia*, 1933, *2*, 277–279.
2. COUNCIL ON PHARMACY AND CHEMISTRY, THOROTRAST. *J. Am. M. Ass.*, 1932, *99*, 2183–2185.
3. FREEMAN, W., SCHOENFELD, H. H., and MOORE, C. Ventriculography with colloidal thorium dioxide. *J. Am. M. Ass.*, 1936, *106*, 96–101.
4. KUBIE, L. S., and RETAN, G. M. Forced drainage of cerebrospinal fluid. *J. Am. M. Ass.*, 1933, *101*, 354–358.

5. LÖHR, W., and JACOBI, W. Die Darstellung der peripheren Nerven im Röntgenbild. *Arch. f. klin. Chir.*, 1932, *171*, 538–554.
6. LÖHR, W., and JACOBI, W. Eine neue Method zur Reliefdarstellung des Zentralnervensystems im Röntgenbild. *Deutsche Ztschr. f. Nervenh.*, 1933, *130*, 15–22.
7. NICHOLS, B. H., and NOSIK, W. A. Myelography with the use of thorium dioxide solution (thorotrast) as contrast medium. *Radiology*, 1940, *35*, 459–466.
8. NOSIK, W. A. Clinical application of thorotrast myelography and subsequent forced drainage; report of case. *Cleveland Clin. Quart.*, 1938, *5*, 262–266.
9. NOSIK, W. A., and MORTENSEN, O. A. Myelography with thorotrast and subsequent removal by forced drainage; experimental study. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 727–730.
10. RADOVICI, A., and MELLER, O. Essai de liquidographie céphalo-rachidienne. Encéphalo-myélographie par le thorotrast sous-arachnoïdien. *Bull. Acad. de méd., Paris*, 1932, *107*, 314–317.
11. RADOVICI, A., and MELLER, O. La liquidographie chez l'homme. *Presse méd.*, 1934, *42*, 153–157.
12. SCHOENFELD, H. H., and FREEMAN, W. Ventriculography and encephalography by means of thorium dioxide solution. *Med. Ann. Dist. Columbia*, 1933, *2*, 279–282.
13. TWINING, E. W., and ROWBOTHAM, G. F. Ventriculography by opaque injection. *Lancet*, 1935, *2*, 122–125.
14. WUSTMANN, O. Experimentelle Untersuchungen über die Reliefdarstellung (Umrisszeichung) des Zentralnervensystems im Röntgenbild durch Thoriumkontrastmittel. *Deutsche Ztschr. f. Chir.*, 1933, *238*, 529–567.

VOL. 49, NO. 2

PYOGENIC OSTEOMYELITIS OF THE THORACIC SPINE PRESENTING AS PRIMARY PULMONARY DISEASE*

By HARRY A. SOLOMON, M.D.,
Visiting Physician, Fourth Medical Division, Bellevue Hospital
and
ARNOLD L. BACHMAN, M.D.,
Radiologist, Triboro Hospital
NEW YORK, NEW YORK

DURING the past decade it has become increasingly apparent that osteomyelitis of the spine is an extremely protean disease which may offer great difficulty in early diagnosis. Various manifestations and presentations of these vertebral infections have been described in the literature. The majority of these reports are concerned with the abdominal symptomatology associated with osteomyelitis of the lumbar vertebrae. Cases with symptoms referable to the dorsal region have been published less frequently.[2,5,6,8,10] Reports of thoracic spine osteomyelitis completely masquerading as a primary pulmonary infection have appeared only rarely.

Pyogenic osteomyelitis of the vertebrae has been described in considerable detail by Wilensky[10] and Kulowski.[6] The disease is almost always of hematogenous origin and tends to involve the lumbar region much more frequently than the thoracic spine. Difference of opinion is held concerning the sites of localization of the infection in the dorsal vertebrae. Thus, Wilensky states that the posterior portions of the vertebrae are involved more frequently than the bodies. Kulowski, however, believes that the bodies and adjacent intervertebral discs are affected most often. In 102 cases involving all regions of the spine he found the bodies involved in 84 instances, the posterior processes in 13 and combined lesions in 5 cases. Many reports of single cases have appeared illustrating both types of infections.

The symptomatology of thoracic vertebral osteomyelitis appears directly influenced by the location of the lesion since the latter determines in which direction the pus will migrate. Involvement of the spinous processes, posterior portions of the pedicles and posterior surfaces of the transverse processes usually results in deeply situated abscesses in the posterior thoracic muscles which finally point at the back of the chest. Infrequently, the suppuration extends internally and results in the formation of an epidural abscess.[1] Localization of the lesion in the anterior part of the pedicles and anterior surface of the lateral thoracic processes is soon followed by a purulent infection in the mediastinum, paravertebral and posterior extrapleural spaces. Osteomyelitis of the vertebral body and adjacent disc is almost invariably complicated by mediastinal abscess. In turn, the mediastinal abscess may spread by direct contiguity, or via the lymphatic channels, and cause an empyema or suppurative pericarditis. Many combinations and variations of these patterns have occurred and have given rise to extremely complex syndromes.

The signs and symptoms of a given case may often be misleading, at least during the early stages of the disease. With involvement of the posterior vertebral processes the high fever, rigidity and fixation of the back muscles, excruciating tenderness over the involved vertebra and superficial pointing of the burrowing abscess at the dorsum

* From the Fourth Medical Division, Charles H. Nammack, Director; and the Department of Pathology, Douglas Symmers, Director; Bellevue Hospital, New York.

of the chest wall usually make the diagnosis apparent after a comparatively short interval. Rarely, in cases of epidural abscess or collapse of a vertebral body, evidence of spinal cord compression is present. Infection of the bodies and intervertebral discs, however, results in a mediastinitis or extrapleural abscess and their complicating empyema or suppurative pericarditis. In these patients the chief complaints and findings are related to the respiratory system, making the proper diagnosis extremely difficult. Superficial pointing of the abscess may occur very late in the course or not at all, and the changes in the spine may be completely masked by the pulmonary syndrome. Thus, in Kulowski's series of 102 cases, mistaken diagnoses were made in 7; 4 cases being originally interpreted as pneumonia and empyema, while 3 patients were originally considered to have cancer of the mediastinum. Hahn[4] reports a case diagnosed and treated in its early stages as pneumonia. Makins and Abbott[7] and Wilensky[10] describe cases in which the true nature of the malady was not appreciated until the postmortem examination.

Roentgenographic examination is extremely important in the diagnosis of pyogenic osteomyelitis of the dorsal spine. The changes encountered are of two types: those confined to the vertebrae themselves and those related to the complications. It is essential that the roentgenograms of the spine have fine bony detail. Oblique views may often be of aid where lesions of the posterior articulating facets are suspected.

During the initial weeks of the disease roentgen evidence of pathological changes in the vertebrae may be entirely lacking.[3,9] One of the early and important roentgenographic signs, and meriting careful search, is destruction of the disc with narrowing of the intervertebral space.[3,6] Changes in trabecular structure occur shortly thereafter. Following these appear the characteristic, dense, reactive new bone formation which results in markedly increased bone density, exostoses and bony bridges. These findings may be associated with mottling, erosion, sequestration, destruction, wedging and collapse due to the destructive effects of the infective process. It is this combination of destruction with dense new bone deposits, exostoses and bridging which characterizes pyogenic osteomyelitis and differentiates it from vertebral tuberculosis. The marked bony atrophy and decalcification observed during the active, early phases of tuberculous spondylitis is almost never seen at any stage of pyogenic osteomyelitis.

Paravertebral mediastinal abscess and suppurative mediastinitis are the most frequent and important complications of osteomyelitis in the dorsal spine. Roentgenographic changes appear early and are characterized by widening of the mediastinum to the right, left or bilaterally. The border of the widened mediastinum is sharply demarcated from the adjacent lung tissue, forming an almost straight or very slightly curved line of separation.[1,2,6,10] The appearance may often be distinguished with ease from the semilunar, arc-like shadows cast by greatly enlarged mediastinal lymph glands. As the infection spreads, mediastinal widening continues and areas of adjacent pneumonitis may appear. Should empyema supervene, the roentgenograms[5] reveal the typical picture of such a condition. Retropleural infections may cast bizarre shadows on the roentgen film, depending upon the shape and position of the localized, peripheral empyemata. Serial roentgenograms are extremely important in accurately following the course, possible spreads and sequelae of the osteomyelitic process.

CASE REPORT

L. R., a white male, aged thirty-three, was admitted to Bellevue Hospital on July 17, 1939. The patient had been in excellent health until February, 1939, at which time cough, expectoration of foul, blood-tinged sputum, pain in the chest, weakness, night sweats, anorexia and loss of weight appeared rather suddenly. The symptoms gradually became worse, weight loss increased, occasional pain was noted in the back of the chest, asthenia became marked and

the patient sought medical aid at the Beth David Hospital, New York City, in May, 1939.

Physical findings on admission to that institution revealed dullness, diminished breath sounds and râles in the left lower portion of the thorax posteriorly. Roentgenograms of the chest (Fig. 1) revealed a large dense shadow in the left mid-lung field, interpreted as a consolidation. A small, sharply demarcated, triangular opacity at the root of the right lung was not thought significant. The patient constantly coughed throughout his entire stay and had a septic, spiking fever. Wassermann and Kline tests were negative. Repeated examination of the sputum failed to demonstrate tubercle bacilli. Roentgenograms of the dorsal and lumbar spine were reported as negative. Roentgenograms of the sinuses showed a bilateral maxillary antral clouding. Bronchoscopy yielded no positive information. Bronchographic examination was reported as showing saccular and cylindrical dilatation of the bronchi in the lower portion of the left upper lobe. While in the hospital the patient received sulfapyridine and symptomatic treatment, including one 500 cc. transfusion. During his stay at Beth David Hospital the cough and physical findings improved only slightly. Serial roentgenograms of the chest were reported as showing no definite change in the lung findings. There was no evidence of a fluid level or lung abscess. Pain in the chest continued unabated; that in the back of the chest was medial in location and apparently was unaffected by respiration. The remittent fever continued, but the levels were somewhat lower than on admission. Further hospital care and observation were deemed necessary and the patient was therefore transferred to Bellevue Hospital with the provisional diagnosis of left upper lobe bronchiectasis.

The patient's past history included an attack of croup in childhood and a mild chronic cough distinctly different from that accompanying the present illness. There were no operations or accidents. He has had carious teeth for many years. The family history was negative for tuberculosis, allergic phenomena or cancer. The patient's mother suffered from diabetes mellitus and died at the age of sixty-two.

Admission examination on July 17, 1939, revealed a poorly nourished male appearing chronically ill. Temperature 102.4° F., respiratory rate 28, pulse 96, blood pressure 120/70. Head: eyes reacted equally to light and in accommodation; the throat was chronically infected; lower jaw edentulous, several upper teeth carious; the gums were inflamed. Neck: no glands or masses; trachea in midline. Chest: symmetrical; percussion dullness on left side posteriorly from T_4 to T_8; bronchial and bronchovesicular breath sounds as well as numerous moist and coarse râles present in this region; the base appeared clear. Moist, crackling râles were also heard in the left anterior axillary region. On the right side moderate dullness was present in the paravertebral region at the level of the scapula. The heart was normal in size; sounds were of fair quality; regular sinus rhythm, rate 96 per minute; no murmurs. Abdomen: liver and spleen not palpable; no masses. Extremities: normal; no clubbing of the fingers. Reflexes: normal.

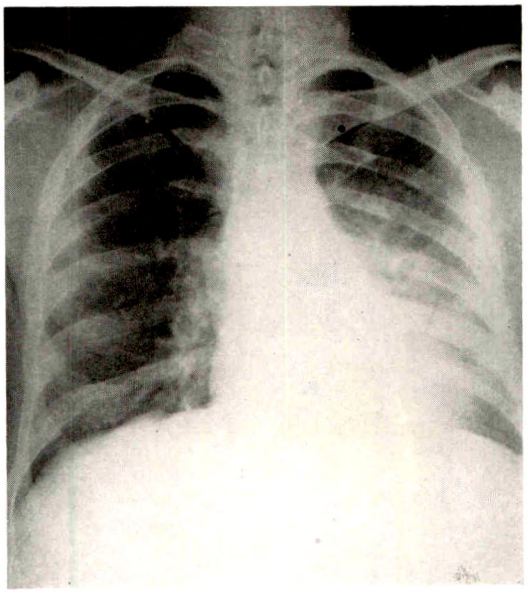


FIG. 1. Large dense shadow in the left mid-lung field. Note the small, triangular opacity at the root of the right lung.

Roentgenoscopy of the chest revealed a marked increase in density in the lower half of the left lung field just above a clear costophrenic sinus. The right lung was clear, but there was a marked increase in the density of the right hilar shadows. This density measured 6 by 10 cm. and presented a somewhat irregular outline.

Admission laboratory examination revealed the urine to be entirely normal. Blood count: hemoglobin 56 per cent; red blood cells

4,230,000; white blood cells 6,900; differential smear showed 77 per cent polymorphonuclear leukocytes, 23 per cent lymphocytes. Wassermann reaction was negative. Erythrocyte sedimentation rate was 138 mm. in one hour.

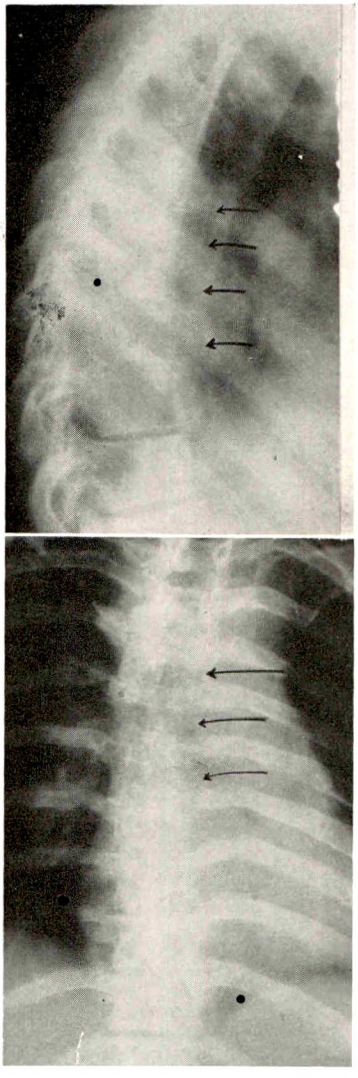


FIG. 2. Anteroposterior and lateral views. Irregular destruction and collapse of bodies of fourth, fifth, sixth and seventh thoracic vertebrae.

Roentgenographic examination of the chest was reported as showing a large patch of unresolved consolidation involving the left upper lobe medially and posteriorly. There was dense perihilar fibrosis and thickening of the mid-third of the axillary pleura on the left side. Blood sugar 114 mg. per 100 cc.; non-protein nitrogen 30 mg. per 100 cc. Sputum analysis showed no acid-fast bacilli. Electrocardiogram revealed some notching of the R waves in lead 3 and left axis deviation, but otherwise was normal.

Admission diagnoses varied between bronchiectasis, resolving pneumonia, tuberculosis and pulmonary neoplasm.

Course: The patient continued to run an intermittent fever with temperatures varying from 99° F. in the forenoon to 103° F. in the afternoon. Repeated sputum analyses were negative for acid-fast bacilli and an intradermal injection of 0.1 mg. of Old Tuberculin caused no reaction. Coughing continued and there was frequent expectoration of bloody mucoid sputum. Re-examination of the chest by roentgen ray now demonstrated a sharply bordered, marked density immediately lateral to the root of the right lung and extending from the clavicle to the lower hilum. This was suggestive of a mediastinal tumor. The moderately dense, diffuse shadow was again observed in the left midlung field. On July 29, 1939, the patient suddenly expectorated 50 cc. of bright red blood, lost consciousness and showed clonic convulsions of the left leg. He was treated for shock and gradually recovered from the acute episode. Bronchoscopy was performed on August 2, 1939, but the examination was not entirely satisfactory. Mucopurulent material was present in the right main bronchus from which a biopsy was taken. There was no evidence of tumor. The septic course continued, the spleen became palpable and severe interscapular pain gradually made its appearance. Repeated urine analyses revealed no abnormality. Blood counts showed no leukocytosis, but the erythrocytes dropped to 3,850,000 and the hemoglobin gradually diminished to 58 per cent. Additional investigation of the sputum consistently failed to reveal tubercle bacilli. A sputum culture resulted in the growth of *Streptococcus viridans*, *Staphylococcus aureus* and fusiform bacilli.

The severe interscapular pain over the dorsal vertebrae gradually increased and tenderness over the spine in this region was elicited. On August 10, 1939, one month after admission, definite weakness and atrophy of the peripheral muscles, especially the interossei, of the right upper extremity were observed. Beginning atrophy of the left interossei also appeared. Other neurological findings were absent. Diagnostic spinal puncture showed the following: initial pressure 120 mm.; the fluid was clear

and contained 2 cells per cubic millimeter; globulin, trace; Wassermann reaction, negative.

The patient continued to bring up between 5 and 15 cc. of bright red blood at frequent intervals and bronchoscopy was repeated. Biopsy again showed only normal tissue. Repeated roentgen examination of the chest demonstrated a gradual increase in the size of the density in the right superior mediastinal region. There was suggestive evidence of pneumonitis in both lungs as well as a possible atelectasis in the right upper lobe. Roentgenograms of the thoracic spine were at this time reported as normal. Another bronchoscopic examination showed no evidence of tumor, but mucopurulent material was seen in the right main bronchus. A blood count performed on August 8, 1939, showed 12,200 white blood cells, of which 88 per cent were polymorphonuclear leukocytes and 12 per cent lymphocytes. The red blood cells had fallen to 3,450,000 and the hemoglobin was 70 per cent (Sahli).

Repeated consultations with the Chest Service resulted in the impression that the mediastinal mass might be a malignant lymphoblastoma. Accordingly, a therapeutic test with deep radiation therapy was given to the right anterior mediastinum. The factors employed were: 200 kv., 20 ma., 0.5 mm. copper and 1.0 mm. aluminum filtration, 50 cm. target-skin distance and a field size of 10 by 15 cm.; 1,000 r was delivered to this skin portal in ten days. No demonstrable improvement or reduction in the size of the mass was observed. Severe interscapular pain, cough with hemoptysis and spiking temperature continued.

On September 16, 1939, two days following the last roentgen treatment and two months after admission, there appeared a fluctuant swelling to the right of the spine at the level of the third to sixth dorsal vertebrae. On aspiration of the region 30 cc. of foul, greenish pus was obtained. Culture resulted in the growth and identification of *B. coli* and *B. lactis aerogenes*. Roentgenograms (Fig. 2) of the thoracic spine on September 25, 1939, revealed for the first time irregular destructive changes in the bodies of the fourth, fifth, sixth and seventh thoracic vertebrae. A roentgenogram of the chest showed a marked widening of the superior mediastinum, particularly on the right, with areas of surrounding pulmonary infiltration (Fig. 3).

The abscess over the dorsal spine gradually increased in size and was accompanied by the expectoration of an increasing amount of purulent sputum. Incision and drainage was performed on September 29, 1939. A large amount of foul pus was withdrawn, revealing a sinus which connected with the diseased, necrotic spinous processes of the third and fourth thoracic vertebrae. Air was observed in the abscess cavity upon opening. Pus and blood were also seen to drain out of the trachea into the pharynx, indicating a connection of the mediastinal abscess with a major airway. Further ex-

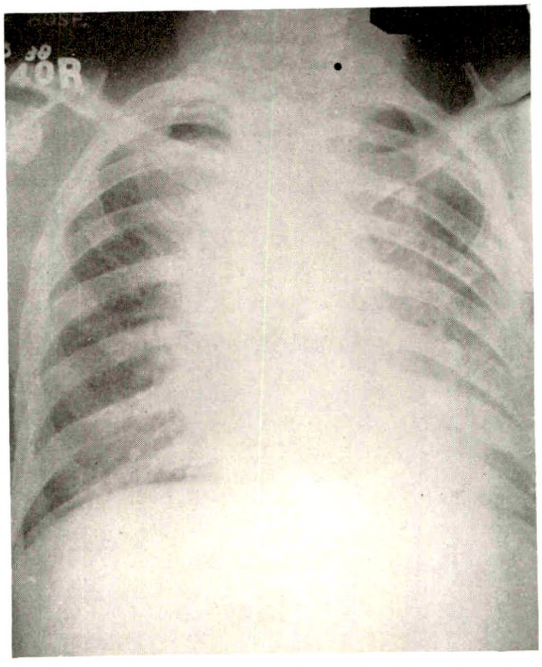


Fig. 3. Marked widening of the superior mediastinum, especially on the right, with areas of surrounding pneumonitis.

ploration revealed the sinus to extend across the bodies of the involved vertebrae to the left side of the chest. From this latter region large amounts of pus drained, the drainage increasing with cough. No further procedure was attempted at this time because of the patient's poor condition, and the wound was packed.

Following operation there was moderate improvement in the patient's general condition. It soon became apparent, however, that drainage was inadequate. Accordingly, a second incision and drainage was performed on October 5, 1939, in the left posterior mediastinal region. The heads of the third and fourth ribs were

resected, exposing a large cavity with a moderate amount of pus. Exploration was accompanied by shock and further procedure was therefore impossible. Postoperative drainage was only moderate and roentgenograms showed the presence of a pyopneumothorax on the left side with drainage tubes in situ at the operative site. Despite supportive therapy the patient's course grew gradually worse and he died on October 25, 1939, about nine months after the appearance of symptoms.

Postmortem examination revealed the following pertinent data:

Gross findings: The body was that of a white male, poorly developed and poorly nourished. In the upper portion of the right chest posteriorly was a 3 inch gaping incision. On the left side a 3 inch vertical, interscapular incision was present. There was no external edema, cyanosis or clubbing of the fingers or toes. Some atrophy of the lumbrical muscles of the right hand was observed.

On opening the chest, the left lung was found markedly reduced in size. The pleura over its entire periphery was considerably thickened, and multiple, dense, fibrotic adhesions were present. A well encapsulated, intrapleural empyema was seen at the apex of the upper lobe which connected with the left sinus draining posteriorly. This empyema cavity extended forward to the anterior chest wall. The lung could not be removed except with considerable difficulty and tearing of the tissues because of the thick adhesions. The right lung had very few adhesions, was large, emphysematous and crepitant. There was no noticeable shift in the position of the heart.

The left lung when removed was found to be much smaller than normal. Its exterior was rough and shaggy because of the tearing during removal. The bronchi were found to contain a considerable amount of clotted blood. No bronchopleural fistula could be demonstrated, possibly because of the destruction of the tissues in removing the organ. On section, the parenchyma was quite firm and compact in appearance. The pulmonary vessels were found to be patent and a definite point of hemorrhage could not be located.

The right lung was found to be quite large, crepitant and emphysematous throughout. Sections showed the tissue to be spongy in appearance. The large bronchi and the right pulmonary vessels were patent.

Upon the removal of the lungs and heart an old inflammatory process in the paravertebral tissues was found at approximately the level of the first to the seventh upper dorsal vertebrae and ribs. This was somewhat more marked on the right than on the left.

The heart, aorta, gastrointestinal tract, kidneys, adrenals, pancreas and lymph node systems all showed no abnormality.

The spleen weighed 300 grams. Its capsule was thin and tense, and the underlying parenchyma was a dirty slate-gray color. On section it cut readily. The cut surface was smooth, moderately friable and the pulp abundant.

The liver weighed 2,100 grams. There was mild congestion of the liver parenchyma. Otherwise, no noteworthy changes were observed either in this viscus or the gall bladder.

Microscopic findings: Sections through the vertebrae, ribs and paravertebral tissues revealed marked granulation tissue reaction with infiltration of many lymphocytes. There was fragmentation of bone with some focal collections of polymorphonuclear leukocytes and lymphocytes. The inflammatory mass in the right and left paravertebral area showed the findings of chronic inflammation: much granulation tissue, many lymphocytes and polymorphonuclear leukocytes. In one section was seen a spicule of bone. There was no evidence of new growth.

Slides of the right lung revealed the cells lining the acini to be edematous and the capillaries engorged. Within the lumina of many of the acini were numerous, large, pink mononuclear leukocytes, the so-called "heart failure" cells. Sections through the left lung showed a pulmonary consolidation, the lumina of most of the acini being compressed or occluded, with an almost complete loss of architecture. Many "heart failure" cells were also present in this section. Red blood cells were seen in the bronchi.

The spleen on section revealed its venous sinusoids to be particularly prominent and the pulp abundant. The liver showed changes of marked, chronic, passive congestion. All of the vessels were dilated. The venous sinusoids were very prominent, resulting in pressure on the liver cord cells.

Sections through the heart, kidneys and prostate demonstrated no noteworthy abnormalities.

Anatomic diagnoses: (1) acute and chronic

osteomyelitis with necrosis of the dorsal vertebrae, first to seventh, and adjacent ribs; (2) chronic mediastinitis with right paravertebral abscess; (3) encapsulated chronic empyema posterior to the apex of the left lung and abscess in the adjacent posterior mediastinum; (4) left parietal chronic pleurisy with multiple, peripheral, fibrotic adhesions; (5) atelectasis of the left lung. Compensatory emphysema of right lung; (6) left bronchopleural fistula; (7) antemortem clot in left main bronchus; (8) slight atrophy of lumbrical muscles of the right hand; (9) mild toxic splenitis; (10) chronic passive congestion of the liver.

COMMENT

From the onset and throughout the seven months of hospitalization the clinical findings suggested a tentative diagnosis of primary inflammatory disease of the lungs. The constant manifestations were pain in the chest, severe cough, profuse expectoration, frequent and severe hemoptysis, dyspnea and sepsis. Roentgenographic examination supported such an opinion since vertebral abnormalities were not seen until late in the course. The early roentgenographic changes were related only to the pulmonary pathology. Thus, reports from the Beth David Hospital mentioned only a diffuse density in the lower part of the left upper lobe and evidence of mediastinitis was not noted.

Because of the profuse purulent expectoration, hemoptysis and suggestive roentgen findings bronchiectasis could be inferred. In the absence of other causes, the possibility of an infected bronchial ectasia resulting from a previously expelled foreign body necessitated consideration. Bronchography and repeated bronchoscopies were therefore performed. Tuberculosis and other specific infections of the lung or bronchus were excluded by roentgen examinations, bronchoscopic and sputum studies. Evidence for abscess or necrosis of the lung was likewise lacking.

Mediastinitis on the right side became definitely apparent on the roentgenograms of the chest taken shortly after the patient's admission to Bellevue Hospital, five months after onset of illness. However, because of the extensive opacity in the left lung field it was not considered likely that all of the chest involvement could arise from a vertebral osteomyelitis. Such a view was apparently supported when roentgenograms of the dorsal spine made at about the same time were described as showing no evidence of disease.

As the mediastinal abscess enlarged the nodular outline of the widened root shadow grew large, lost its sharp delineation from the surrounding lung tissue and suggested the diagnosis of mediastinal lymphoma. The presence of a palpable spleen appeared to confirm this diagnosis, and the destructive vertebral changes which appeared later were ascribed to bony extension of the lymphoma. Deep roentgen therapy of the abscess which was mistaken for lymphoma was soon followed by pointing of the mediastinal suppuration with paravertebral abscess formation and accentuation of the septic state.

The bilateral brachial plexus nerve root signs due to pressure associated with the diseased vertebrae, and indicated by weakness of the arms and atrophy of the small muscles of the hand, developed late in the course of the illness. However, a noteworthy manifestation of vertebral involvement which was present from the onset was the fixed, supine position which the patient constantly assumed. Always bedfast during his entire hospitalization period he would not raise his body even to control a severe coughing spell or expectorate, and would eat his meals lying flat in bed.

Roentgen evidence of osteomyelitis with destruction of the dorsal vertebrae finally became apparent seven months after the onset of symptoms, concomitantly with the superficial pointing of the abscess. By this time the vertebrae were completely riddled with the pyogenic infection and the disease had become far advanced.

At autopsy the destruction of the dorsal vertebrae by pyogenic osteomyelitis was very extensive, and the other changes were essentially those of suppurative mediastin-

itis. No gross bleeding areas in the bronchi were found to explain the severe and frequent hemoptyses which apparently were due to congestive changes alone.

SUMMARY

In the developing clinical picture of pyogenic osteomyelitis of the spine, the paravertebral complications, local or distant, may commonly appear as the primary condition while destruction of the spine may progress extensively and, unfortunately, remain unrecognized. Any case with high fever, pain in the back over the spine and roentgenographic evidence of mediastinal widening (mediastinitis) should have the possibility of pyogenic dorsal vertebral osteomyelitis excluded regardless of other pulmonary signs, symptoms or roentgenographic appearances and despite the failure to demonstrate changes in the vertebrae on the roentgenograms.

In conclusion, the clinical, pathological and roentgenographic features of this condition are discussed and an illustrative case with autopsy findings reported.

REFERENCES

1. BRILL, N. Q., and SILBERMAN, D. E. Pyogenic osteomyelitis of the spine, mediastinal abscess and compression of the spinal cord. *J. Am. M. Ass.*, 1938, *110*, 2001–2002.
2. BROWDER, J., and MEYERS, R. Infections of spinal epidural space; aspect of vertebral osteomyelitis. *Am. J. Surg.*, 1937, *37*, 4–26.
3. CALDWELL, G. A. Osteomyelitis of vertebrae; report of nine cases. *Tri-State M. J.*, 1937, *9*, 1816–1820.
4. HAHN, O. Ueber die primäre akute Osteomyelitis der Wirbel. *Beitr. z. klin. Chir.*, 1895, *14*, 263.
5. KULOWSKI, J. Unusual pyogenic osteomyelitis. *J. Missouri M. Ass.*, 1935, *32*, 85–94.
6. KULOWSKI, J. Pyogenic osteomyelitis of the spine; analysis and discussion of 102 cases. *J. Bone & Joint Surg.*, 1936, *18*, 343–364.
7. MAKINS, G. H., and ABBOTT, F. C. On acute primary osteomyelitis of vertebrae. *Ann. Surg.*, 1896, *23*, 510–539.
8. SCHWARZ, E. Ein Beitrag zur Frage der Osteomyelitis der Wirbelsäule mit Beteiligung des Rückenmarks. *Beitr. z. klin. Chir.*, 1920, *119*, 151–159.
9. SUSSMAN, M. L. Chronic osteomyelitis of the spine. *Acta radiol.*, 1933, *14*, 43–51.
10. WILENSKY, A. O. Osteomyelitis; its pathogenesis, symptomatology and treatment. Macmillan Company, New York, 1934, pp. 410–412, 414, 417–419

VOL. 49, NO. 2

THE THERAPEUTIC VALUE OF ROENTGEN TREATMENT IN CHRONIC ASTHMA

By WAYNE M. HULL, M.D., RAY M. BALYEAT, M.D., *and* L. K. CHONT, M.D.
OKLAHOMA CITY, OKLAHOMA

THE treatment of asthma by radiation was probably first observed by Schilling in 1906, following prolonged roentgenoscopic examination of an asthmatic sufferer. Treatment by irradiation of the chest was later advocated in 1926 by Scott[10] in London, who reported favorable results in 21 cases of chronic asthma. He discovered that easier breathing frequently followed irradiation of breast carcinoma which suggested to him the possibility of roentgen therapy for the relief of asthma. Beneficial results have been reported from time to time from radiation treatment to various parts of the body, particularly the spleen, liver, pituitary gland, long bones, and other regions.

Scott's interest in the treatment of asthma by radiation stimulated a more systematic investigation of the asthmatic problem by selecting patients who were definitely asthmatic sufferers and free of other complications, particularly breast carcinoma. He used low voltage and emphasized the importance of exposing large fields of the entire trunk to irradiation. He believed that relief was obtained in practically every case treated, and noticed that within twenty-four hours there was usually an increase in the amount of mucus expectorated from the bronchial tubes.

In 1929 Scott[11] reported a series of 121 cases of asthma treated by radiation in which 89 obtained definite benefit. He pointed out the importance of careful roentgenological examination of the chest in all cases previous to treatment. He remarks that a definite fibrosis at the roots of the lungs is present in practically all asthmatics, which he believes to be a secondary condition since no changes were detected even after irradiation had been successful. The majority of his cases had used the numerous remedies and methods of treating asthma, including cigarette smoke, adrenalin products, medicated inhalers, etc., and were in nearly every instance in desperate circumstances.

Probably the first systematic treatment of asthma by radiation in this country was applied at the Mayo Clinic by Maytum and Leddy[5,6] between the years 1931 and 1934. In the original report of some 23 patients, 5 were markedly relieved for many months, while 8 obtained marked relief for shorter periods. In 1939 Maytum and Leddy[7] reported another series, comprising 215 patients, which they treated between 1935 and 1938. Twenty-four per cent of this group obtained more than 75 per cent relief which lasted from one to four years. A large part of this group (161 cases) received no other treatment. Twenty-three patients, or 14 per cent, received as much relief, but in addition to the roentgen therapy were put on the regular treatment for asthma.

Observations on the treatment of our first series of 100 consecutive cases over a six months' period, focused our attention unexpectedly upon the importance of infection in the asthmatic problem. Due to the superior results from the roentgen therapy in those infected cases, the selection of the 1,500 patients treated since has been made easier.

Although a number of investigators have used roentgen therapy in the treatment of asthma, none have considered fully the importance of infected accessory nasal sinuses as an etiological and aggravating factor in severe cases. The majority of our patients who received roentgen therapy to the chest, also received radiation therapy to the accessory sinuses whenever they were found involved. We regard routine roentgenograms of the chest and sinuses in all asthmatic patients as very important and

whenever evidence of infection was found in the paranasal sinuses radiation therapy was administered.

Among the first to report the value of irradiation in the treatment of the nasal accessory sinuses were Butler and Woolley[1,2] at the University of Oregon, who published their results in 1934. They reported on 450 of 700 patients with chronic sinusitis treated with roentgen therapy, and considered that 36 per cent were cured, 55 per cent improved, and 9 per cent slightly improved or not helped. From their studies they concluded that patients with hyperplastic membranes are the most likely to be helped, while those with polypi, atrophic rhinitis, chronic sinusitis, fibrosis, and those who had been unsuccessfully treated by radical surgery were the least benefited.

TABLE I

AVERAGE DURATION OF SYMPTOMS FOR VARIOUS AGE GROUPS IN 100 CASES OF ASTHMA

Age (years)	Duration (years)
0–10	2.0
11–20	5.0
21–30	11.0
31–40	11.8
41–50	17.6
51–60	11.3
61–70	7.5
71–80	7.7

The work of Butler and Woolley has later been confirmed by others interested in the roentgen therapy of the sinuses, particularly by Firor and Waters.[3] The latter, like Butler and Woolley, studied membrane sections from the sinuses before and after treatment in experimental animals and occasionally humans. They all agree that irradiation should not be used in acute sinusitis but can be used with beneficial results in the other types, especially subacute sinusitis and chronic sinusitis with thickened membranes.

In the group treated by Firor and Waters, cures were reported in 34 per cent, 38 per cent were considered markedly improved in which the symptoms disappeared completely in a short time, while 13 per cent were only slightly improved or not relieved at all. These figures coincide fairly closely with the results obtained by Butler and Woolley. Firor and Waters concluded that approximately 70 per cent of properly selected cases of sinusitis can be cured or markedly improved by irradiation. They regard the presence of a leukocytic infiltration in the sinus membranes an important factor for good results, thus explaining the negligible results in cases of fibrosis and atrophic changes where leukocytes were not found. Other workers, including Rathbone,[9] Hodges,[4] Osmond,[8] and others, have obtained similar results with roentgen treatment of the accessory sinuses.

The average age incidence of asthma is shown in the accompanying graph (Fig. 1) in which it will be observed that the most frequent occurrence of asthma in our series of patients lies in the age group forty to fifty, or 26 per cent. The age groups from twenty to thirty, thirty to forty, and fifty to sixty, show approximately an equivalent incidence. The lowest incidence of asthma occurred between the ages of seventy to eighty, and ten to twenty, while the incidence in children under ten years represents 10 per cent of all cases. The average duration of asthma in all patients included in this group is eleven years and seven months (Table 1).

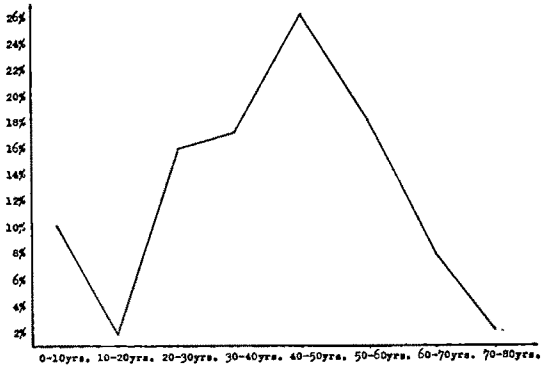


FIG. 1. The age incidence in a series of 100 consecutive cases of asthma.

The protocol reveals some interesting facts regarding infection, where we find that in 58 per cent of this series the white blood count ranges between 7,000 and 11,000 white blood cells per cubic millimeter. In 32 per cent the white blood count was above 11,000, but in only 10 per cent was it below 7,000. We have always regarded the white blood count as somewhat significant in evaluating the presence of infection in asthmatic individuals and generally more significant than the finding of organisms in the expectorated sputum, since large numbers of bacteria may be found in the bronchial secretions without necessarily causing trouble, while in other individuals even small numbers of organisms may produce very marked effects. A comparison of the white blood count before and after treatment is even more confirming when in practically every instance the blood count can be seen to drop as infection is eliminated. Figure 2 shows graphically the elevation of the white blood count before and after treatment in this series of cases. One can almost state that an elevation of the white blood count in asthmatic patients is significant of infection either in the bronchial tubes or in the sinuses, when, of course, the presence of infectious processes elsewhere in the body has been eliminated.

The presence of protein products from bacteria in the bronchial tubes may possibly produce two effects, one in which the protein simply irritates the bronchial tubes, and the other due to specific sensitization to these proteins, either or both of which may cause severe bronchial spasms. In other cases, the presence of bacteria probably stimulates bronchial secretions with accumulation of mucus, and it is well known that mucus alone may incite severe bronchial spasms. This view is certainly supported by observation of those individuals who clear up gradually but surely as the amount of mucus decreases during or after treatment.

The clinical response in most patients followed closely the decrease in the white blood count. Reference to Figure 2 shows that in all patients with chronic asthma and superimposed bronchial infection the range of the white blood count lies between 8,000 and 15,000 per cubic millimeter. The increase in polymorphonuclears is not significant and rarely occurs. Following radiation therapy, there is an almost immediate drop in the white blood count which tends to persist and eventually reaches an approximate normal level, usually quite early in the course of treatment.

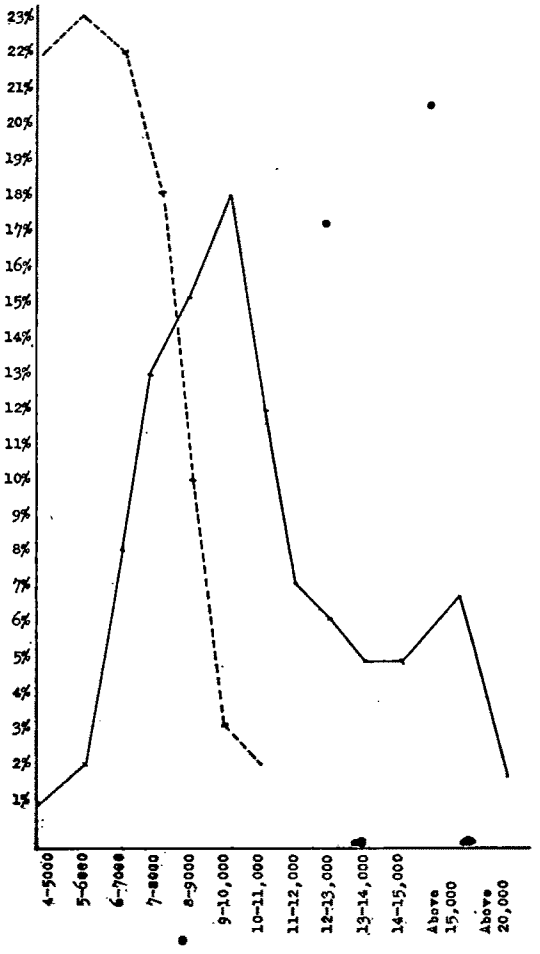


FIG. 2. The white blood count before and after radiation treatment. Before treatment——; after treatment----.

Table II reveals that in this series of patients, 24 per cent brought up no mucus at all, 11 per cent a slight amount of mucus, and 22 per cent only moderate amounts.

The remainder, or 43 per cent, expectorated large amounts, and in 51 per cent of all patients the secretions were found infected. Since various strains of organisms are normally found in the bronchial tubes, as well as the upper respiratory passages, it has not always been possible to say when a specimen from any individual is definitely infected. It is possible, with reasonable care, in practically every case to obtain cultures of either streptococci or staphylococci from the material even in normal individuals. We have regarded those patients infected who bring up mucus that is green, yellow, or yellowish-green, and where the white blood count is elevated. The common strains of streptococcus organisms are not pigment producing bacteria (except *Streptococcus pyogenes*) and the mucus is clear or gray. The temperature in these patients is usually normal, although an elevation of one or two degrees may occur in acute cases.

TABLE II

INCIDENCE OF MUCUS AND INFECTION

None	24%	
Slight	11%	
Moderate	22%	
Heavy	43%	
Infected		51%

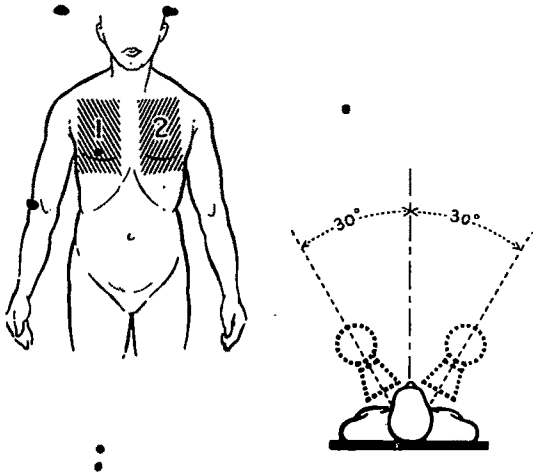


FIG. 3. Showing portals 1 and 2, angulation of tube for the "cross fire" technique to the anterior chest.

Our treatment of asthmatic patients by radiation therapy has varied somewhat in technique from that used by others. In this country Maytum and Leddy, and those employing this type of treatment, have advocated the so-called direct technique in which the purpose is that of concentrating the greatest amount of radiation in the hilar regions and the mediastinum. We have felt that irradiation should be more effective when distributed over a larger area of the lung where the bronchial tubes are most numerous and therefore have employed a so-called "cross fire" technique in which six distinct field areas of the chest are irradiated. The first fields are exposed with the patient lying on his back with the tube set at about a 45 or 60 degree angle, first on the right side and then on the left side. The average individual receives about 100 roentgens of filtered radiation to each field, and since two fields are irradiated at the same sitting the total dose is about 200 r daily. The next treatment is given to the corresponding fields of the posterior chest with the tube directed at an oblique angle from the posterior lateral aspect. The lateral fields are given by direct irradiation to the sides of the chest. Two exposures are generally given to each field in the course of the treatment, depending on the severity of the case and the amount of involvement in the bronchial tubes. Thus in the average individual a total dosage of between 800 and 1,600 r is administered through six portals. In severe cases where infection is great, or where the amount of purulent mucus is considerable, the total dosage may be increased above that for the average individual. Likewise, for milder cases and in children, the dosage is considerably below the average.

Figures 3, 4 and 5 show graphically the so-called "cross fire" technique which we have employed in the treatment of our patients. The majority of cases in the first series received irradiation by the direct method, as advocated by Maytum and Leddy, with most of the dosage directed in the region of the mediastinum. We have

been led to believe that irradiation of larger areas of the chest has given better results.

Most of our patients expectorated variable amounts of mucus. It was interesting to observe that generally within a period of three days to three weeks most individuals coughed up large amounts of thick, stringy, purulent mucus, oftentimes pitted with plugs, and usually in greater amounts than had previously occurred. In practically all cases where the individual was able to rid himself of large amounts of mucus, improvement was almost instantaneous and proportionate to the amount brought up. Generally within two or three weeks the expectoration of mucus had entirely ceased, and along with this change the patient became free of asthma. Sometimes the mucus changed a great deal in consistency, becoming more liquid or less tenacious and easier to bring up. At other times it changed in color but it always increased in amount temporarily, then gradually decreased until the individual became free of both mucus and asthma.

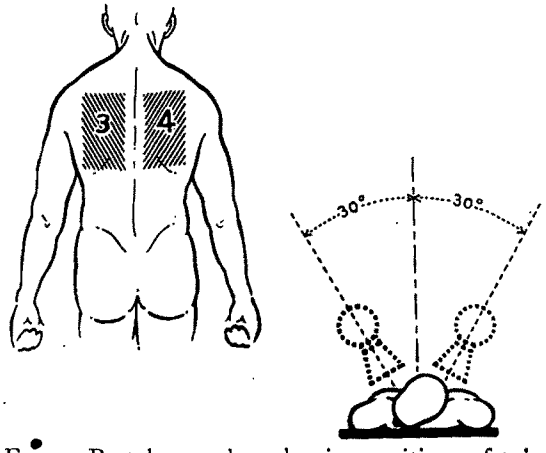


FIG. 4. Portals 3 and 4, showing positions of tube for "cross fire" technique to the posterior chest.

We have been able to follow this series of patients over a period of eighteen months, and during the first year from one to three courses of radiation therapy have been given. Fifty per cent of the cases were in the first group and received only one course of treatments during the first twelve months; 35 per cent were in the second group and received two courses; 15 per cent were in the third group in which three courses were given (Table III).

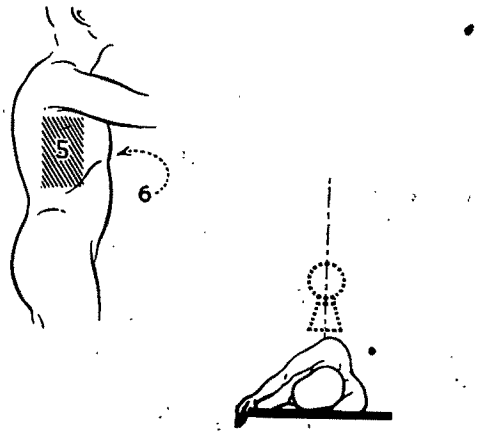


FIG. 5. Direct irradiation to lateral aspects of chest through portals 5 and 6.

TABLE III

NUMBER OF ROENTGEN COURSES FIRST YEAR

One course	50%
Two courses	35%
Three courses	15%

One course of treatment consists of fractional daily doses, totaling from 600 to 1,600 roentgens.

As to results, we have classified them as excellent, good, fair, poor, and none at all (Table IV). The table shows that they were divided as follows: Excellent, 39 per cent; good, 40 per cent; fair, 13 per cent; poor, 6 per cent; no results, 2 per cent. It has not been a simple matter to classify these individuals from a standpoint of results obtained, and this grading has been made entirely on the basis of each individual's

TABLE IV

APPROXIMATE RESULTS OF ROENTGEN THERAPY IN SERIES OF 100 CONSECUTIVE CASES OF ASTHMA

Excellent	39%
Good	40%
Fair	13%
Poor	6%
None	2%

progress during the course of eighteen months. We regard those with excellent results to represent patients who have been almost completely relieved, without recurrence of attacks during the eighteen months' period. Those with good results are individuals who have been almost completely relieved, although they may have had occasional light attacks that required the use of some simple aid such as the nebulizer, or tablets, or some other one of the various commonly used drugs. Some of these individuals received their second course of treatments during the year. Patients in the group regarded as obtaining fair results for the most part required three courses of radiation therapy during the twelve months period, and in addition to that had some trouble most of the time with occasional hard attacks of asthma that required the use of adrenalin hypodermically for relief. Those regarded as poor were not benefited by the treatment as far as we could tell. It is, of course, not fair to say that the good results were obtained because patients received radiation therapy, as they also received regular treatment consisting of desensitization where indicated, removal of offending foods, careful attention to the environmental factors, etc.

So far there have been no complications of the treatment other than nausea, which occurs in practically all patients, but it is not severe and quickly subsides within two or three days following the treatment. A few cases have complained of headache following irradiation of the sinuses. There have been a few patients sufficiently nauseated to vomit. Routinely all cases receiving radiation therapy are given 5,000 units of vitamin B_1 daily hypodermically. In those few individuals where nausea became marked, it was almost invariably controlled quite satisfactorily by injections of liver extract.

There are two possible dangers that must be considered in irradiation of these individuals. First, excessive irradiation may produce a pulmonary fibrosis; second, too much irradiation may produce roentgen burns of the skin. In order to avoid any possibility of occurrence of either process, we have kept accurate records on all patients as to the date of each treatment, the area treated, filters used, and total dosage, in addition to the distance and the voltage. We are confident that the amount of radiation given to these patients is within a safe range of dosage. We are sure that we are not producing a pulmonary fibrosis, and we are reasonably certain that the dosage can be repeated a number of times at intervals of three to four months or longer without danger of roentgen burns of the skin or damage within the chest. The amount of radiation which we are giving to the average patient could be repeated each year over a period of eight to ten years. The greatest danger appears to be in the possibility of these patients being treated in different parts of the country by irradiation without knowledge of previous exposure, as the treatment becomes accepted by others doing this type of work.

CONCLUSIONS

Although this group represents a series of 100 consecutive patients, the first we have treated by radiation therapy, we know our technique has greatly improved and that the next 1,529 patients following this group which have been treated have shown better results. Not only has the technique been more thoroughly standardized, but we have been able to select more accurately those individuals who could be expected to obtain most benefit. We are able at this time to offer the following conclusions on this method of treatment of severe asthma complicated by infection:

1. We are able to control asthma in many individuals who did not respond satisfactorily to methods previously used.
2. Radiation therapy in asthma is of definite value in those patients who show infection either in the bronchial tubes, the paranasal accessory sinuses, or both.
3. Infection has proved to be of greater importance in the asthmatic problem than previously regarded because of the remark-

able response of these individuals to radiation therapy.

4. Radiation therapy in asthmatic sufferers free of infection seems to have little or no effect.

5. The choice of technique is in favor of the "cross fire" method in which the dosage is concentrated over the greatest areas of the lungs where most of the bronchial tubes are distributed.

6. The method is not without danger but can be regarded as safe when accurate, detailed records are kept on each individual, and where the amount of radiation is maintained within a safe range of dosage.

7. We believe that irradiation of larger areas of the chest has given better results.

REFERENCES

1. BUTLER, F. E., and WOOLLEY, I. M. Roentgen therapy in chronic sinusitis. *Radiology*, 1934, *23*, 528–537.
2. BUTLER, F. E., and WOOLLEY, I. M. Roentgen treatment of chronic sinusitis. *Radiology*, 1938, *30*, 686–690.
3. FIROR, W. B., and WATERS, C. A. Present status of roentgen treatment of sinus infections. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *42*, 857–865.
4. HODGES, F. M. Roentgen therapy of infections of nasal accessory sinuses. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 578–584.
5. MAYTUM, C. K., and LEDDY, E. T. Roentgen treatment of severe asthma. *J. Allergy*, 1936, *8*, 66–70.
6. MAYTUM, C. K., and LEDDY, E. T. Roentgen therapy for severe asthma. *Texas State J. Med.*, 1937, *32*, 610–612.
7. MAYTUM, C. K., and LEDDY, E. T. Roentgen treatment of asthma. *J. Allergy*, 1939, *10*, 135–145.
8. OSMOND, J. D. Roentgen therapy of acute infections of antrum and frontal sinus. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 374–377.
9. RATHBONE, R. R. Roentgen therapy of chronic sinusitis in children. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 102–108.
10. SCOTT, S. G. Method of treating asthma by radiation. *Brit. M. J.*, 1926, *1*, 939–941.
11. SCOTT, S. G. Treatment of asthma by radiation. *Brit. M. J.*, 1929, *1*, 9–11.

RADIUM THERAPY AS AN AID IN THE CONTROL OF CHRONIC OTORRHEA

By ERNEST B. EMERSON, JR., M.D.
Division of Otolaryngology, Department of Surgery, and
ANDREW H. DOWDY, M.D.
Department of Radiology
University of Rochester, School of Medicine and Dentistry, and Strong Memorial Hospital
ROCHESTER, NEW YORK

CROWE and Baylor[1] in 1939 mentioned the fact that some cases of otitis media improved following radon treatments of the eustachian orifice for deafness. They did not, however, elaborate further on the subject. In 1941 Crowe and Burnam[2] further state that their radon method of treating the eustachian adenoid tissue has no effect on chronic otitis media. With these two statements in mind, we wish to present some evidence that, in certain selected cases of chronic otorrhea, treatment of the eustachian orifice with radium may be of value in controlling the otorrhea. We believe that as long as chronic otorrhea continues to form a large part of any otological practice, any specific therapy which may aid in the control of the otorrhea is of the utmost importance. We do not offer the method as a specific for all cases of chronic otorrhea.

We first noted improvement in cases of chronic otorrhea in the course of treating with radium the eustachian orifice of children with eustachian adenoids and hearing curves showing a predominant high tone loss. This observation led us to sort out from our files a large group of cases of chronic otitis media and revaluate them in respect to the possible etiology of their otorrhea.

The cases chosen for treatment with radium were those in which the persistent otorrhea appeared, on physical examination, to be due to hypertrophied lymphoid tissue in and about the eustachian orifice. All lesions of the upper respiratory tract, such as deviated nasal septum, sinus disease, tonsils and adenoids, which might contribute to the persistent otorrhea were excluded. Patients showing additional middle ear disease, such as polyps, granulations, caries of the ossicles, and patients with physical signs of mastoiditis of an active nature, were not included in the group to be treated. Roentgen examination was not made, as cases of chronic otitis media usually show a sclerotic mastoid and we felt, therefore, that the films would be of minimal value to us. The nasopharynx and the eustachian orifices were inspected directly with the nasopharyngoscope, using a 2 per cent pontocaine anesthesia in the nose to facilitate passage of the instrument.

The minimum amount of radium necessary to carry out the treatments is 25 milligrams (two 12.5 mg. needles). Each needle *per se* is composed of an alloy having a density of 8.7 and walls 0.3 mm. thick. Such a needle transmits 99.2 per cent of the gamma rays. Of the total amount of radiation emanating from these needles, a relatively high percentage is beta radiation.

The applicator for carrying out the radium treatments is the same as that used in the treatment of deafness with radium.[3] The entire applicator consists of three parts —head, cap, and handle. The head is composed of two parallel chambers open at one end, and with brass walls 1 mm. thick. It is 3 cm. long, 0.6 cm. wide and approximately 3.5 mm. thick. There is an oval window 1.5 cm. long on one side of the head so that when it is placed in its treatment position against the os of the eustachian tube the radium is unfiltered other than the filter supplied by the walls of the needles. When loaded for treatment each chamber of the head contains one 12.5 mg. radium needle. The cap holds the two needles in place. It is an oval, flat piece of brass, 1 mm. thick

and of sufficient size to cover the open ends of the chambers in the head. There is a small hole in one end of the cap just large enough to allow the passage of the threaded end of the semiflexible steel wire handle. On the other end of the cap and on the underneath side is a small steel plug which fits in to the open end of one chamber of the head. The open end of the other chamber is threaded. When the threaded end of the handle is screwed into this, it not only retains the needle in place in the chamber, but also holds the cap on, which in turn secures the other needle firmly in its chamber. The semiflexible wire handle is 13.4 cm. long.

In order to save time in carrying out the treatments, we have constructed two such instruments, one the mirror image of the other. Previous experience in treating hemangiomata on the mucous membrane in children with these needles in contact and without additional filtration has established the erythema dose to be between 12 and 15 mg-hr. In view of the relatively high degree of sensitivity of lymphoid tissue to irradiation, we felt that approximately one-third of an erythema dose (5 mg-hr.) should be sufficient. Such a dose requires a treatment time of twelve minutes to one eustachian tube orifice, or twenty-four minutes if both orifices are treated with one applicator containing 25 mg. of radium. If four such needles (50 mg. of radium) are

TABLE I

CASE NO.	NAME	SEX	AGE	EAR	DURATION OF OTORRHEA	CULTURE	DATE OF RADIUM TREATMENT	DURATION OTORRHEA AFTER RADIUM	DRUMS AFTER RADIUM TREATMENT	HEARING AFTER RADIUM TREATMENT	RECURRENCE OTORRHEA AFTER RADIUM TREATMENT
1	C.R.	F	25	BILATER'L	20 YRS +	STAPH. A.	6-11-41	4 WKS	RT. HEALED LT. PARTIALLY HEALED	++++	NONE IN 3 MOS.
2	J S.	M	20	RIGHT	INTERMITTENT	DRY	7-9-41	NONE	UNCHANGED	NO DATA	NONE IN 2 MOS.
3	J S.	F	10	LEFT	INTERMITTENT	DRY	12-3-40	NONE	UNCHANGED	++++	NONE IN 9 MOS.
4	J.M.	F	16	BILATER'L	16 YRS.	STAPH A H	1-22-41	2 WKS.	UNCHANGED	+	1 MO. LATER FOR 3 DAYS NONE IN 8 MOS.
5	J.P	M	17	LEFT	15 YRS.	STAPH A. H.	6-4-41	4 WKS	UNCHANGED	++++	NONE IN 3 MOS.
6	D.N.	M	15	LEFT	3 YRS.	NEG.	8-6-41	NO CHANGE	PERFORATION SMALLER	+	NO CHANGE
7	E.K.	F	8	RIGHT.	8 YRS.	STAPH A. H.	5-28-41	2 MOS	HEALED	+++	NONE IN 2 MOS.
8	B.C.	F	14	RIGHT	14 YRS.	STAPH A H.	1ST 10-2-40 2ND 11-20-40	1 WEEK 1 WEEK	UNCHANGED	+ NO CHANGE	NONE IN 10 MOS.
9	A.C.	M	25	BILATER'L	25 YRS.	STAPH A.	12-10-40	NONE	UNCHANGED	+	NONE IN 9 MOS.
10	I.D.	F	15	BILATER'L	12 YRS	STAPH. A.	11-13-40	NO DATA	HEALED BY SCARRING	+	NONE IN 10 MOS.
11	R F.	M	14	LEFT	NO DATA	STAPH A.	5-5-41	2 WKS	UNCHANGED	+	NONE IN 4 MOS.
12	F T.	F	13	LEFT	9 YRS.	B. PROTEUS	12-11-40	DISCHARGE LESS	UNCHANGED	+	DISCHARGE LESS
13	G.H.	F	6	RIGHT	7 MOS.	STAPH A.	1-8-41	1 MO	UNCHANGED	+++	8 MOS. LATER FOR 4 WK.
14	I. L.	M	12	LEFT	5 YRS.	B. PYOCYANEUS	11-6-40	3-5 DAYS	UNCHANGED	+	NONE IN 10 MOS.
15	G.P	F	15	RIGHT	4 YRS.	B.PROTEUS-STAPH A.	11-11-40	DISCHARGE LESS	UNCHANGED	NO CHANGE	DISCHARGE LESS
16	M.L.	F	15	LEFT	7 YRS.	B PROTEUS	10-23-40	2 WKS	UNCHANGED	NO CHANGE	NONE IN 11 MOS.
17	A.C.	M	25	BILATER'L	23 YRS. +	STAPH. A. H.	12-10-40	1 WK.	UNCHANGED	+	NONE IN 9 MOS.
18	R J.	M	17	RIGHT	17 YRS	B PROTEUS	12-11-40	NONE	UNCHANGED	++++	NONE IN 9 MOS.
19	E.J.	M	11	RIGHT	11 YRS.	STAPH. A.	2-19-41	NONE	UNCHANGED	++++	NONE IN 7 MOS.
20	G.N.	F	23	LEFT	7 MOS	STAPH. A.	1-29-41	DISCHARGE LESS	UNCHANGED	NO DATA	PATIENT LOST
21	D.G.	M	16	BILATER'L	10 YRS.	STAPH A.	9-3-40	3 MOS.	RT HEALED LT PARTIALLY HEALED	++++	NONE IN 12 MOS.
22	I. L.	F	15	LEFT	5 MOS.	STAPH. A.	10-16-40	10 DAYS	HEALED	++++	NONE IN 11 MOS.
23	B.C.	F	14	RIGHT	10 YRS.	STAPH A H.	1ST 10-4-40 2ND 11-20-40	1 WEEK 10 DAYS	UNCHANGED	+ NO CHANGE	1 MO. LATER FOR 10 DAYS NONE IN 10 MOS.
24	M.B.	M	12	RIGHT	10 YRS. +	STAPH. A.	6-18-41	5 DAYS	UNCHANGED	NO CHANGE	1 MO. LATER FOR 8 DAYS NONE IN 2 MOS.
25	M.B.	F	15	RIGHT	INTERMITTENT	DRY	5-14-41	NONE	UNCHANGED	+	NONE IN 4 MOS.
26	M.C.	F	7	LEFT	5 YRS.	STAPH A B. ALKALIGENES	7-23-41	± 2 WKS.	UNCHANGED	++	NONE IN 2 MOS.
27	B.C.	F	14	RIGHT	INTERMITTENT	DRY	10-2-40	NONE	UNCHANGED	+	NONE IN 11 MOS.
28	J.C.	M	10	BILATER'L	INTERMITTENT	STAPH. A. DIPHTHEROIDS	2-26-41	3 WKS	UNCHANGED	NO DATA	NONE IN 7 MOS.
29	P L	M	8½	BILATER'L	8 YRS. +	B. PROTEUS	1ST 11-27-40 2ND 9-17-41	4 WEEKS 4 WEEKS	UNCHANGED	++ +	7 MOS. LATER FOR 4 WKS. NONE IN 1 MO.
30	S. P.	F	13	RIGHT	13 YRS.	STAPH. A.	10-2-40	NO DATA	NO DATA	NO DATA	PATIENT LOST

+— 25 per cent improvement in hearing.
++— 50 per cent improvement in hearing.
+++— 75 per cent improvement in hearing.
++++—100 per cent improvement in hearing.

available and two applicators are used, both orifices can be treated simultaneously in twelve minutes after local anesthesia has been established.

We have found the application of one treatment of 5 mg-hr. (one-third of an erythema dose) sufficient in most instances.

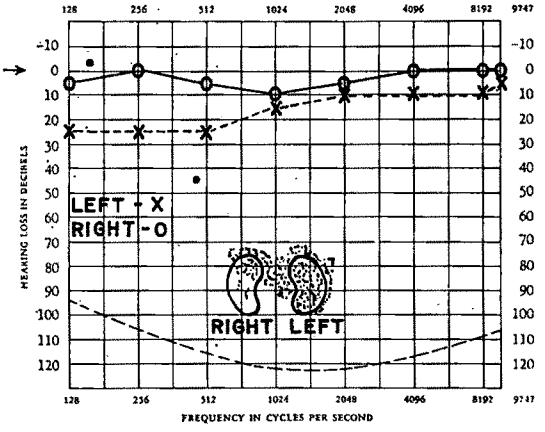


FIG. 1. Case 1. June 4, 1941. Prior to radium treatment. This patient showed a marked defect in the hearing of the left ear. The relative amount of adenoid tissue about the eustachian orifices is shown schematically.

Occasionally, a second treatment of like magnitude has been necessary in three months in order to bring about the desired results.

The actual treatment is carried out in the otology clinic. Following local anesthesia with 2 per cent pontocaine, the head of the applicator is passed through the inferior meatus with the oval window in the head toward the lateral wall. Owing to the shape of the applicator it will drop into position in contact with the eustachian tube orifice and remain fixed throughout the treatment.

Table 1 shows the results obtained in the treatment of chronic otorrhea in 30 carefully selected cases. In 4 cases healed drums resulted, and in 2 of these 4 cases the otorrhea had existed for ten and for twenty years, respectively. Five cases had recurrence of otorrhea. Two of these recurrences followed swimming and were of short duration, clearing without subsequent radium treatment. In 2 of the cases the recurrent otorrhea ceased following a second dose of radium. One case was without frank otorrhea, but the middle ear remained moist. In 3 cases we were unable to obtain a dry ear; 2 of these had less otorrhea, but in 1 case we failed entirely. All of these patients have received such other treatment of routine nature as was indicated. One additional case is mentioned which is not included in the charts. This case developed a surgical mastoid following an upper respiratory infection.

The following 4 cases are selected from a group of 35 cases treated. The 35 patients treated were carefully chosen in respect to the aforementioned criteria from over one hundred and fifty cases of chronic otitis media. The 4 cases illustrate the effectiveness of the treatment on the chronic otorrhea due to eustachian lymphoid hypertrophy and also show the effect on the hearing curve.

CASE 1 (Fig. 1 and 2). J. P., white male, aged seventeen, was first seen in the Otological Clinic of Strong Memorial Hospital on June 4, 1941. A history of intermittent otorrhea bilaterally following scarlet fever at two years of age was obtained. The otorrhea on the left had been constant for the last two years. Examination revealed a healed drum on the right, and a large

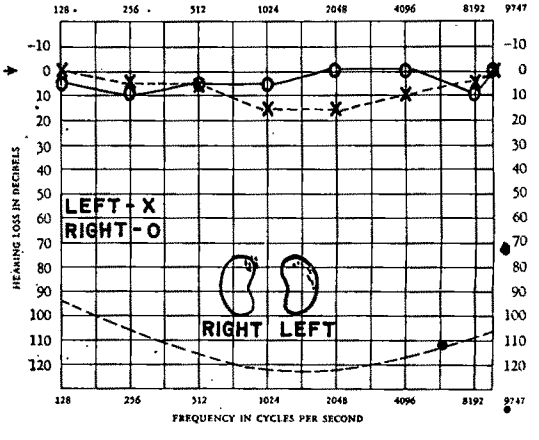


FIG. 2. Case 1. July 16, 1941. Six weeks following radium treatment. Audiogram shows marked improvement in hearing of the left ear, and the eustachian orifices are clear of hypertrophied lymphoid tissue. No otorrhea for one year and three months.

central perforation of the left drum, with otorrhea from which was cultured *B. proteus*. No granulations or polyps were seen in the left middle ear. There was adenoid tissue about the eustachian orifices, especially on the left. A 5 mg-hr. dose of radium was given June 4, 1941, by the intranasal route. Re-examination on July 16, 1941, showed both ears dry, the left drum showed no indication of healing. A good

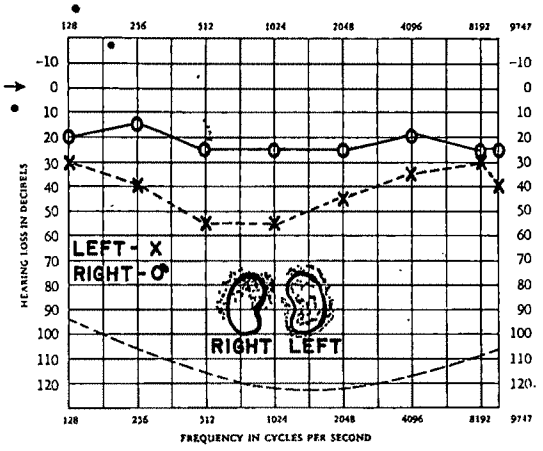


FIG. 3. Case II. The audiogram done May 27, 1941, shows the state of the patient's hearing previous to radium therapy. Again the eustachian orifices, represented schematically, show profuse studding with hypertrophic lymphoid tissue.

improvement in hearing was also noted, especially for the left ear, and the eustachian orifices appeared clean. There has thus far been no further otorrhea.

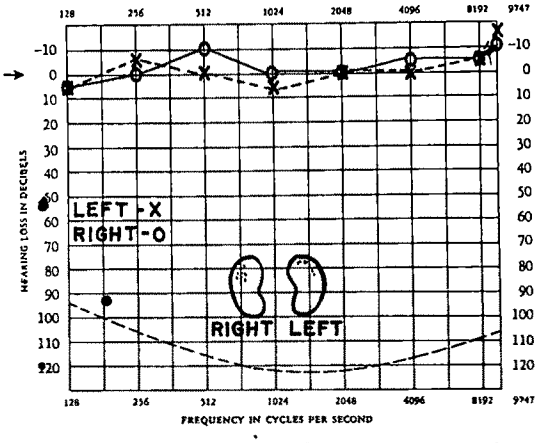


FIG. 4. Case II. Audiogram of August 6, 1941, shows a remarkable return in hearing and the eustachian orifices showed no hypertrophic lymphoid tissue. No otorrhea for three months.

CASE II (Fig. 3 and 4). C. R., white male, aged twenty-five, was first seen in the Deaf Clinic of Strong Memorial Hospital on May 27,

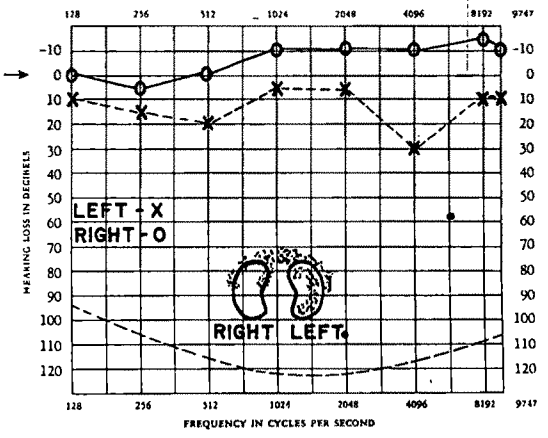


FIG. 5. Case III. Audiogram prior to radium treatment shows marked defect in hearing of the right ear, and there is profuse lymphoid hypertrophy about the eustachian tubes. Radium treatment given June 18, 1941.

1941. A history of ear disease since the age of nine months was obtained. His tonsils and adenoids had been removed in childhood. Otorrhea had been constant bilaterally for the

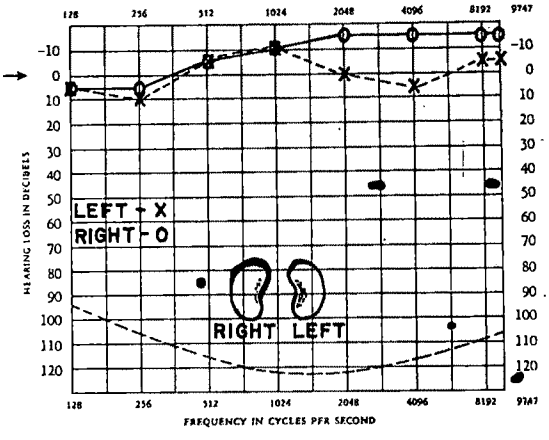


FIG. 6. Case III. One month later the audiogram showed some improvement in hearing of the right ear, and the eustachian tubes were clean. No further improvement in the hearing is expected in this case.

past five years. Examination showed a moderate sized perforation of the right drum and the left drum was completely destroyed. There appeared to be no caries of the ossicles, and no

granulations in the middle ears. Both eustachian orifices were heavily studded with lymphoid tissue, especially the left. Culture of both ears showed *Staphylococcus aureus*. A 5 mg-hr. dose of radium was given by the intranasal route. Examination on August 6, 1941, showed the right drum healed without scarring, the

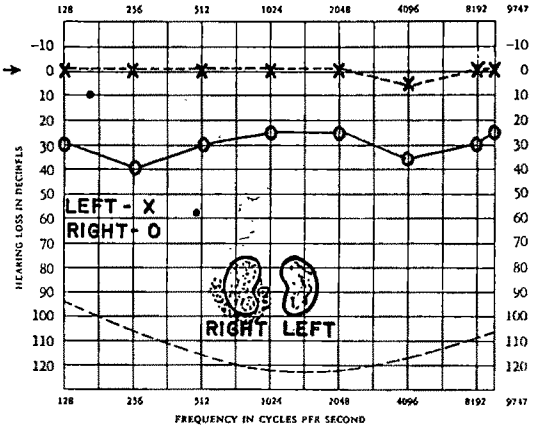


FIG. 7. Case IV. Audiogram prior to radium therapy shows rather marked defect in the left ear, and profuse bogginess of both eustachian orifices is charted schematically.

left drum partially closed and the middle ear was dry. The eustachian orifices were open. The patient had also had an excellent return of hearing.

CASE III (Fig. 5 and 6). M. B., white male, aged twelve, was first seen in the Otological Clinic of Strong Memorial Hospital because of constant otorrhea on the right for seven years; intermittently the discharge had been profuse and foul. Examination showed the left ear to be normal, but the right drum had been entirely destroyed with a fairly profuse discharge from which *B. proteus* was cultured. The tonsils and adenoids were chronically infected. Tonsillectomy and adenoidectomy were performed April 8, 1941, after which the discharge lessened but did not cease. Nasopharyngoscopy revealed swollen edematous eustachian orifices with hypertrophied lymphoid tissue about them. A 5 mg-hr. dose of radium bilaterally was accordingly given on June 18, 1941. The otorrhea on the right soon ceased and on re-examination July 16, 1941, the ear was completely dry. There had been no healing of the drum, and the eustachian tubes were open. The audiogram at that time showed very little improvement over the original hearing curves. The patient is now to receive a course of nicotinic acid in an effort to further improve the hearing in the right ear.

CASE IV (Fig. 7 and 8). P. L., white male, aged eight, was first examined at Strong Memorial Hospital on November 3, 1939, because of persistent otorrhea on the left since the age of four months. Examination showed the right ear to be normal. Both lower quadrants of the left drum had been destroyed and the discharge was foul and profuse. Tonsils and adenoids were removed cleanly at the age of five years. Culture of the aural discharge showed Friedländer's bacillus. The usual conservative measures of ear drops and dry wipings were prescribed. The otorrhea still persisted, but no granulations or polyps were noted in the left middle ear. Diffuse hypertrophy of the lymphoid tissue about the eustachian orifices was seen on November 11, 1940, and a 5 mg-hr. dose of radium was given by the usual intranasal route. By December 12, 1940, the ear was nearly dry and a slow improvement in hearing was noted. By April 2, 1941, the ear was dry, the eusta-

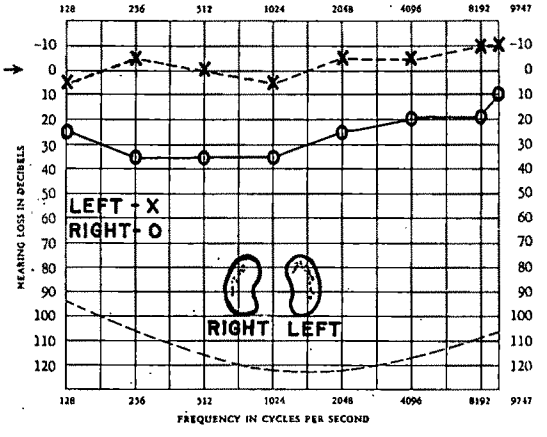


FIG. 8. Case IV. A year and a half later a nice improvement in hearing is seen, the ear dry, and the eustachian orifices clean.

chian orifices open, and there had been a good but not complete return of hearing. On the patient's last visit in December, 1941, the ear was still dry, the drum showed no evidence of healing, and the hearing showed no further improvement.

DISCUSSION

The 4 cases serve to illustrate what may be expected in selected cases of chronic

otorrhea treated with radium. The technique of the treatment is exactly the same as used in the treatment of deafness and was described by us in detail in our previous paper.[3] The dose is also the same, i.e., 5 mg-hr. of radium to each eustachian tube, repeated in six weeks to three months, if necessary.

It is important to remember that cases, to show good results, must be carefully selected. Patients who show concomitant chronic lesions such as ossicular caries, aural polyps or granulations, and involvement of the mastoid, will not show cessation of the otorrhea from irradiation of the eustachian tubes alone, but must have treatment, as indicated, for the middle ear lesions as well. It must be reiterated that pre-existent infectious processes or anatomical malformations of the upper respiratory tract may result in failure of the radium treatment of these cases. In suitable cases, the duration of the otorrhea seems not to be important.

The degree of healing noted in the tympanum will vary from none at all to complete sealing by what appears on inspection to be normal or scarred drum tissue or by thin atrophic membrane. If, as indicated above, there are polyps, caries of the ossicles, granulations, or severe involvement of the mastoid, the results of this treatment are not so satisfactory. Irradiation will, however, be of some aid in the treatment of these more complicated cases, especially if the eustachian orifice is found to be deeply buried in hypertrophied lymphoid tissue.

The irradiation of the eustachian orifice in these selected cases has been a definite aid in the control of the chronic otorrhea. In 4 instances the drums have healed and in these cases only can we say that the treatment cured the patient. The rest of the cases continue to have perforated drums and thus are open to reinfection from without as was the case with 2 patients who went swimming. Again the ears may start to discharge after a recurrent upper respiratory infection. To illustrate this, we cite a case which had cessation of otorrhea following treatment and which, after a severe nasopharyngitis, had a recurrence of the otorrhea and developed a surgical mastoid. From the above it is seen that the method described is by no means a cure for chronic otitis media, but in those cases where cessation of otorrhea is obtained, the patients are relieved of a most annoying symptom and the hearing may be improved as well.

CONCLUSIONS

1. A simple and effective means of treatment of selected cases of chronic otorrhea with a single small dose of radium has been described.

2. The cases suitable for treatment with radium are those in which persistent otorrhea is accompanied by hypertrophied lymphoid tissue about the os of the eustachian tube, and in which concomitant middle ear and active mastoid disease do not exist.

3. Healing of the tympanic membrane may occur, varying in degree from none at all to complete repair.

4. Pre-existent upper respiratory disease should receive the necessary attention, if the best results from irradiation of the eustachian tube are to be expected.

5. The hearing may be improved.

6. In those cases with persistent tympanic perforations, recurrence of the otorrhea may result either from without or from extension of an infectious process in the nasopharynx.

We wish to express our thanks to Dr. Clyde A. Heatly for making this work possible.

REFERENCES

1. CROWE, S. J., and BAYLOR, J. W. Prevention of deafness. *J. Am. M. Ass.*, 1939, *112*, 585–590.
2. CROWE, S. J., and BURNAM, C. F. Recognition, treatment and prevention of hearing impairment in children. *Ann. Otol., Rhin. & Laryng.*, 1941, *50*, 15–31.
3. EMERSON, E. B., JR., DOWDY, A. H., and HEATLY, C. A. Use of radium in treatment of deafness by irradiation. *Arch. Otolaryng.*, 1942, *35*, 845–852.

RADON TREATMENT

MILD RADIUM THERAPY; DEFINITION AND METHOD OF APPLICATION

By STEPHEN KLINGHOFFER, PH.D.
BUENOS AIRES, ARGENTINA

I. GENERAL CONSIDERATIONS

THE discovery of radium led at first to the hope that radium salts could in one way or another be used, not only locally, but also for their effect on the body as a whole. Therefore the attempt was made to determine the dose of radium, either internally or by injection, which could be safely used. Here, however, obstacles arose which were difficult to overcome because of the complexity of treatment by radioactive bodies. Even now these difficulties have not been completely surmounted owing to a lack of proved biological facts, a perfectly clear understanding and a precise definition of the desired end to be attained.

II. TOXICITY OF RADIUM AND MESOTHORIUM

Difficulty arose from several reports showing that radium salts, several years after their ingestion, manifested an extreme and entirely unexpected toxicity. Numerous cases were published. For example, Flinn,[5] in 1932, reported the death of an individual who for two years and a half had been taking a water ("Radithor") containing 2 micrograms of radium salts per dose and whose body contained 40 micrograms of radium. Symptoms of severe poisoning (bone sarcoma) were observed in women workers in a watch factory who painted the watch dials with phosphorescent zinc sulphide containing radium and who were accustomed to point their brushes with their lips. In 1936 Dechaume[2] published several cases of necrosis of the jaw following injection of mesothorium.

These irreversible lesions caused by radioactive bodies resemble, to a certain extent, those observed in "strong" radium therapy (exceeding 5 mg.) used in the treatment of cancer, and are the result of two different properties of radium. The first of these properties consists of regular radioactive power, with the emission of gamma, beta, and especially alpha rays. The second, which is unexpected, is the affinity of long-lived radioactive bodies (radium, mesothorium) for certain tissues, especially the bone marrow and the bone cortex, an affinity similar to that of other metals of the calcium order for the skeleton. Because of this, deposits of radium or other radioactive substances are formed in the body and act as permanent sources of alpha, beta and gamma radiations, which after a quasi-inactivity of five, ten or even fifteen years are capable of bringing about the most serious conditions: bone necrosis, destruction of the bone marrow with consequent anemia, osteosarcoma, etc.

Thus, although Flinn[5] at first believed that a deposit corresponding to 10 micrograms of radium was the limit tolerated, his later observations and the observations of others point to the lowering of this limit to 1 microgram or even to a fraction of a microgram (Hirschi and Bodmer,[9] Rajewsky[13]).

Therefore, long-lived radioactive substances such as radium and mesothorium should be completely eliminated from "mild" radium therapy. They should be used only in short, local applications, suitably filtered, with the object of destroying a definitely limited mass of pathological tissue. The same is true of "radioactive salts," "radiferous earths" and "salts of rare earths," descriptions which should never be used in therapy because of their vagueness in designating complex products containing salts of radium or mesothorium. Their toxicity is unpredictable and they should not be used therapeutically as long as their composition is not definitely known and clearly defined.

III. HARMLESSNESS OF SHORT-LIVED RADIOACTIVE SUBSTANCES

On the other hand, no accidents have been reported after the use of short-lived radioactive substances of the type represented by radium emanation of radon. Up to now, in fact, doses as high as 100,000 millimicrocuries* a day (Happel[7]) ingested by mouth apparently have caused no ill effect; at least none have been reported. In addition, Hirschi,[8] Fernau and Smereker[4] have plainly demonstrated the absurdity of the idea that in such doses radon could be toxic. Innumerable experiences at radioactive and thermal spas, such as Luchon, Gastein, and others, are significant. It is obvious that if the daily ingestion of radon by the inhabitants of such spas, year after year and generation after generation was harmful, the geographical pathology would long ago have shown this fact.

At Joachimsthal, Czechoslovakia, where the miners work all through the year in an atmosphere of considerable radioactivity (2×10^{-12} to 6×10^{-12} and even 2×10^{-11} millimicrocuries per cubic centimeter), the malignant pulmonary tumors observed are now considered to be due to the dust of arsenic and chromium and particularly of radium contained in the air of the mines, not to radon itself. If radioactivity has any part in the production of these tumors, it is in the dust containing radium salts or other long-lived substances. Flinn[6] believes, however, that the presence of radon in the air may have had an effect on the absorption of some toxic metals but concludes that if there is a toxicity of radon at all, it may appear in other organs rather than in the lung.

IV. DEFINITION

These considerations lead us to give what has hitherto been lacking—a precise definition of "mild" radium therapy, internal radium therapy or radon therapy. It is a method of treatment in which radioactive substances are used internally by ingestion, or externally by local application, such as is done at radioactive spas (by drinking, by baths or by mud). However, in "mild" radium therapy doses larger than in the spas can be used in order to obtain better results without provoking any irreparable lesions in the body. This is in distinction to "strong" radium therapy which does cause such lesions and which is used almost exclusively in the local destruction of neoplastic tissue.

* 1 millimicrocurie equals 10^{-9} curie

V. PREPARATION OF RADON

Radon is the only substance which can be considered suitable in mild radium therapy, although Weil,[17] Duvoir and Layani,[3] and some others, have for years used thorium which undoubtedly entails greater risks than radon. The preparation of radon for therapeutic use entails considerable obstacles on account of its short life and requires, therefore, complicated procedures. All radioactive preparations with radon as base and free of radium have hitherto had to be prepared as they were needed. An emanation producing apparatus was necessary into which the vehicle (water, oil, charcoal, etc.) had to be introduced for an exactly determined time in order to be charged with radon to the desired extent. After this time, the preparation should be used without delay as delay would decrease its radioactivity.

VI. AUTHOR'S METHOD

The method which was devised for biological investigations in the presence of a constant concentration of radon obviates this grave disadvantage. It is based on the principle that, in a closed space, it is possible to bring about a radioactive equilibrium between a determined quantity of radon and an insoluble salt of radium measured in such a way as to replace exactly, and so to speak, atom for atom, the radon which disappears in the course of its natural disintegration. It is obvious that this method must be adapted to the nature, to the chemical properties, and above all, to

the physical properties of the medicament with which one desires to combine the radon. In addition, it will be necessary to make adjustments for the various vehicles whose choice is determined by the disease and the method of administration. There are, therefore, described the adaptations for the following methods of administration.

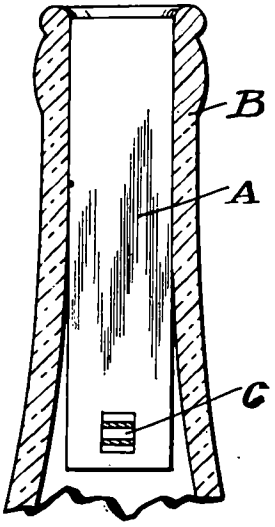


Fig. 1

a. *Oral Administration.* A constant degree of radon can be maintained in mineral waters, both naturally and artificially radioactive. The method consists of introducing into the bottle when it is being filled either at the radioactive spring or, if it is artificial, in the factory, a strip of mica (Fig. 1) (*A*) which is held to the neck of the bottle (*B*) by its elasticity. This strip serves as support for a glass tube (*C*) containing in the form of an insoluble salt, the quantity of radium which is exactly in equilibrium with the radon contained in the water. For the sake of safety, the radium salt is separated from the liquid by a semipermeable membrane.

Dosages of radioactivity extending over several years have demonstrated an absolute constancy in the radon content, without revealing the slightest trace of radium in the water.

The same method may be applied to any other medicines preserved in bottles.

b. *Subcutaneous, Intramuscular or Intravenous Injection (Vesical Instillation).* Figure 2 shows an ampule containing a radioactive liquid for injection. The insoluble radium salt is enclosed in the semipermeable membrane (*D*) and inserted between two plates (*E*) of unoxidizable metal, fastened on a support (*F*) which is elastic, keeping the apparatus in a fixed position inside the ampule (*G*). In this form the device can be sterilized, even in the autoclave.

For subcutaneous and intramuscular injections, as well as for vesical instillations, an oily vehicle is recommended. This permits the complete utilization of the radon employed because of its high degree of solubility in oil, which is more than 100 times that of its solubility in water.

c. *Rectal and Vaginal Administration (Suppositories).* In order to maintain a constant content of radon in suppositories, the insoluble radium salt which is to maintain equilibrium with the quantity of radon contained in the suppositories is placed in such a way that it is easy to withdraw it at the time of use (Fig. 3). This radium salt is placed in the cavity (*H*) of the metal support (*I*) and covered evenly with a very fine membrane applied directly on the metal

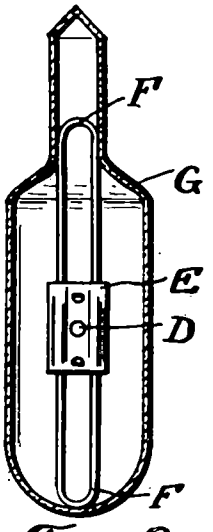


Fig. 2

support, the latter being buried in the radioactive suppository (7). In order to prevent loss of emanation through diffusion in the air, the suppository is placed in a glass tube (*K*) hermetically sealed by the stopper (*L*).

Before using, the suppository is removed from the receptacle in which it is enclosed and the support (*I*) is withdrawn.

It should be noted that this method permits the choice of any vehicle whatever for the radon. It may be a gas, a liquid solution (aqueous or oily), or a solid (fatty substance, gelatin, etc.), the choice being made by consideration of the rapidity of diffusion or elimination, which is, in the last analysis, the solubility of radon in each medium.

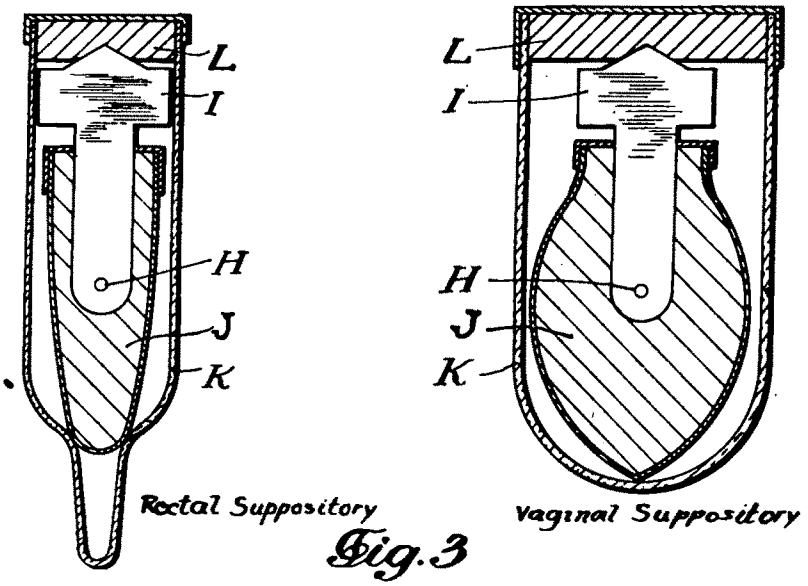


Fig. 3

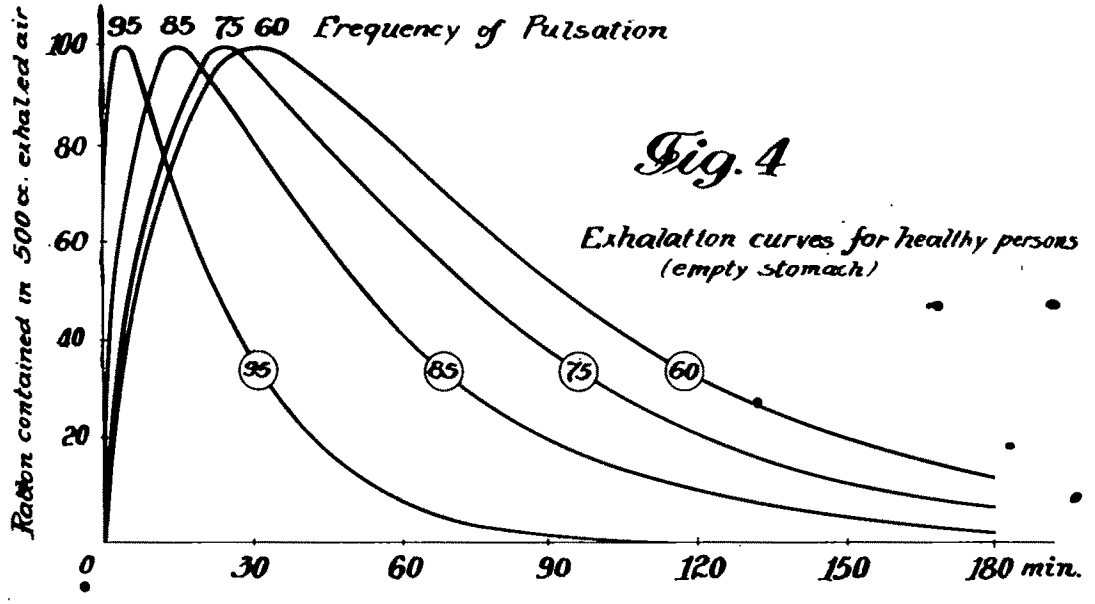


Fig. 4

Exhalation curves for healthy persons (empty stomach)

VII. THE ELIMINATION OF RADON.

The largest part of radon ingested is eliminated by the lungs. In normal persons speed of elimination generally depends on

the pulse rate. A person with a very rapid pulse will eliminate radon much more rapidly than one with bradycardia. Figure 4, which was taken from a publication by Meyer,[12] shows the experimental results of this exhalation. In general, it may be stated that radon is completely eliminated at the end of two or three hours (Fig. 4).

A sick person eliminates radon in a different way from a perfectly healthy one. Thus the curve of elimination depends largely on the disease. The following illustrations show some curves by Meyer for patients with pulmonary disease (Fig. 5), and pneumothorax (Fig. 6). Also, if the radon has been taken orally, elimination will vary according to whether or not ingestion was made on an empty stomach (Fig. 7). The radon water may also have been taken in small sips. Figure 8 clearly illustrates this point.

If the quantity of water and radon in-

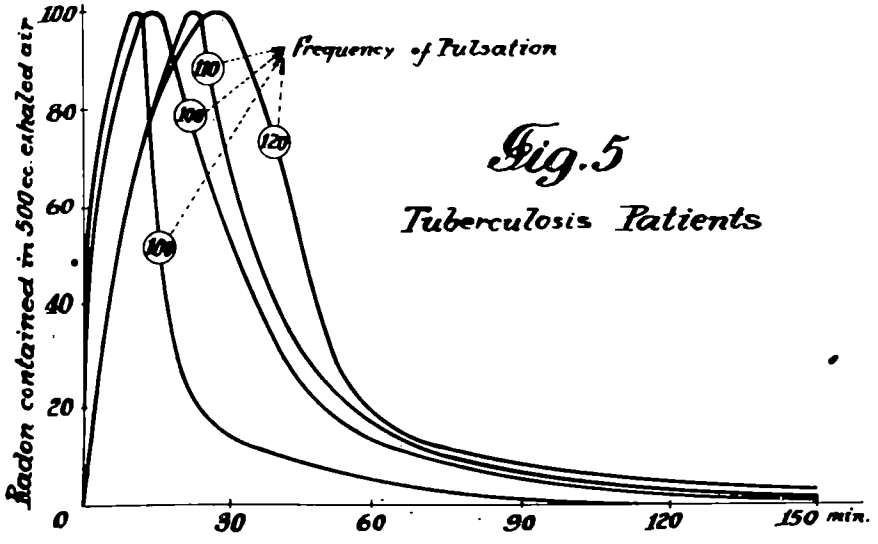


Fig. 5

Tuberculosis Patients

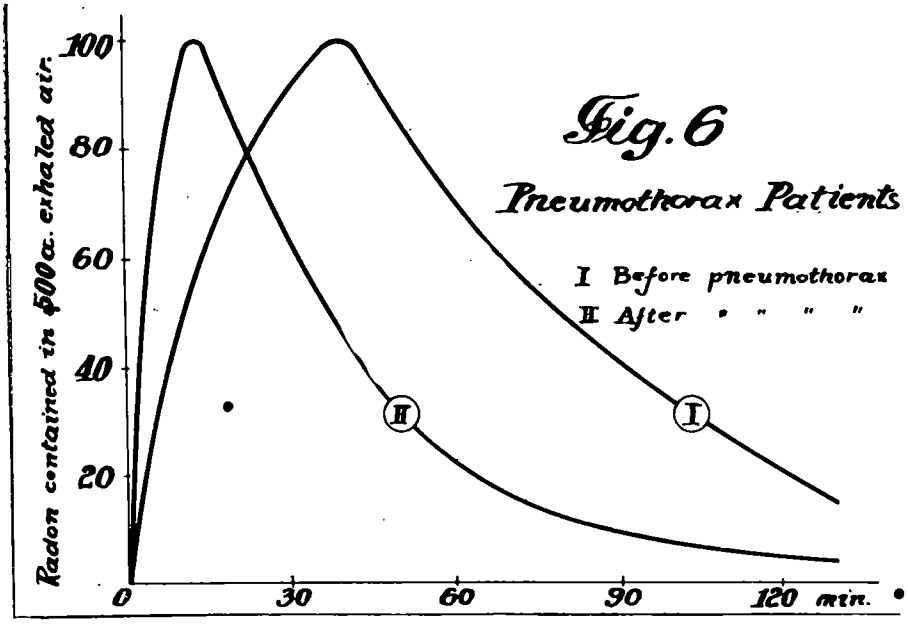


Fig. 6

Pneumothorax Patients

gested at one time gives the curve just seen, the same dose taken at ten different times, a tenth every five, ten or twenty minutes, gives wavy curves with lower summits.

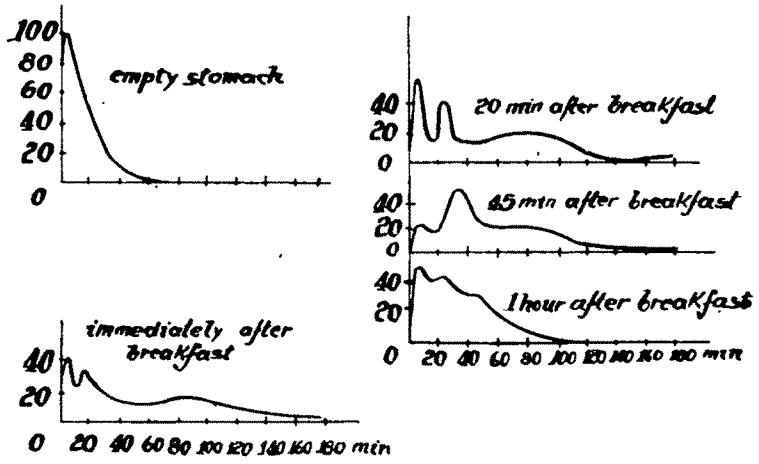


Fig. 7

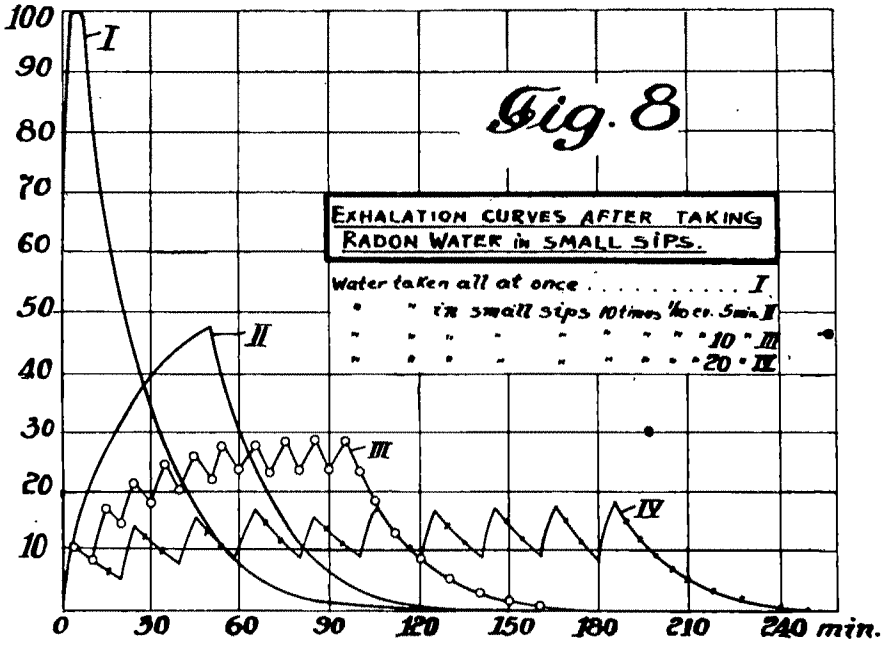


Fig. 8

Thus the body can be kept almost constantly under the influence of radon and its action may be prolonged.

In comparing Figures 7 and 8, it is apparent that the action may be prolonged just as well by ingesting radon in small doses as by absorbing it all at once, for example, after a meal when the stomach is full. This phenomenon is explained by the presence in the stomach of a certain quantity of fats. At room temperature these latter absorb about 100 times as much radon as water does. Consequently these fatty substances are slow to give up the radon they contain in solution. Also, radon taken after a meal is not diffused in the body as

quickly, for it is retained in the digestive tract as long as the fats themselves. It is fixed much more strongly by fats than by aqueous liquids which constitute the principal mass of the bodily tissues.

From a practical point of view, then, it is better to administer radon in the form of a fatty ointment. This has been done effectively for more than twenty years, especially in local treatments.

This method should be more generally used for it yields results greatly resembling (as shown by Meyer[12]) those attained by ingestion in small mouthfuls; that is, it maintains the body under the radon influence, if not continually, at least for a prolonged time, while the aqueous solution has only a momentary effect.

The solutions in fatty substances may be used not only for the skin, but also for all the natural cavities: rectum, vagina, bladder, urethra, nose, pharynx, bronchi, and perhaps even the pleura (oleothorax).

VIII. CONSTITUTION OF THE ACTIVE DEPOSIT

There remains now the question of the posology of radon; but for that one must examine the question of the constitution of the active deposit.

In emitting radiations, all radioactive substances, radon included, give birth to a succession of new radioactive elements belonging by their origin to one of the three radioactive groups. These constitute the "active deposit," in the case of radon, Ra A, Ra B, Ra C, Ra C′, Ra C″, Ra D, Ra E, and finally Ra F or polonium.

Ra A, Ra B and Ra C disappear so rapidly that they need not be considered. Actually the period of demi-transformation of Ra B, the longest living of these substances, is only 26.8 minutes. Only Ra D—whose demi-transformation is sixteen years—and its successors, need be taken into serious consideration. According to Hirschi's[8] calculation, oral ingestion of 4,000 millimicrocuries daily is followed by the elimination of 3,960 millimicrocuries. This leaves 40 millimicrocuries which disintegrate in the body and consequently help to create an active deposit of radium D. These 40 millimicrocuries a day, in the course of a year will accumulate in the body the following amounts of Ra D, Ra E and Ra F:

Ra D	8.6×10^{-11} grams
Ra E	3.8×10^{-14} grams
Ra F	4.6×10^{-13} grams

As a matter of fact, a large part of these substances is eliminated from the body before acting on the tissues, a phenomenon which has not been taken into consideration in these calculations but which is nevertheless important, as lead, for instance, whose chemical affinities are similar to Ra D, disappears from the tissues to a great extent and in a relatively short time.

Fernau and Smereker[4] also made calculations, adopting as a starting point the daily ingestion of 3,640 millimicrocuries. Their figures for the active deposit are:

Ra D	5.06×10^{-12} grams
Ra E	3.13×10^{-15} grams
Ra F	8.23×10^{-14} grams

The rate of accumulation in the body of Ra D, Ra E, Ra F(polonium), calculated by Hirschi, corresponds to that found by Fernau and Smereker, the apparent difference arising principally from the fact that Hirschi, as mentioned above, did not take into consideration the fact that these three substances are partially eliminated.

Let us now consider the effects that such a deposit may produce. From the chemical viewpoint, it may be noted that Ra D, Ra E and polonium are respectively isotopes of lead, bismuth and tellurium. The idea of chemical toxicity from these three simple substances in doses of 10^{-15} to 10^{-11} gram (0.000,000,000,001 to 0.000,000,01 milligram) is, without doubt, untenable. There remains the question of physical toxicity, which may result from the energy liberated in the form of beta rays of Ra D and Ra E and alpha rays of polonium. If we take as the basis of these calculations the results obtained by Hirschi, that is, purposely overlooking the elimination of Ra D, Ra E and Ra F, which may go as high as 90 per

cent of the quantity ingested, the calculation may be made as follows: 8.6×10^{-11} gm. of Ra D contains $8.6 \times 10^{-11} \times 2.88 \times 10^{21}$. $= 2.48 \times 10^{11}$ atoms. The radioactive constant of Ra D being $1.00 \times 10^{-9} \times \text{sec}^{-1}$, the number of atoms which disintegrate per second will be: $2.48 \times 10^{11} \times 1.00 \times 10^{-9} = 2.48 \times 10^{2}$. Granted that, according to Rutherford,[15] the disintegration of Ra D emits 1.5 beta rays per atom disintegrated and the energy produced by each of these rays is on an average 6.21×10^{-8} ergs, the energy liberated per second will be as follows: $2.48 \times 10^{2} \times 1.5 \times 6.21 \times 10^{-8} = 23 \times 10^{-6}$ or 2.3×10^{-5} ergs.

Proceeding in a similar fashion for Ra E, whose radioactive constant is $1.66 \times 10^{-6} \times \text{sec}^{-1}$ and which emits, per atom disintegrated, 1.06 beta rays each having an energy of 4.491×10^{-7} erg, the energy liberated per second by 3.8×10^{-14} grams of Ra E is: $3.8 \times 10^{-14} \times 2.88 \times 10^{21} \times 1.66 \times 10^{-6} \times 1.06 \times 4.491 \times 10^{-7} = 8.65 \times 10^{-5}$ ergs.

In calculating the energy liberated by 4.6×10^{-13} grams of polonium it must be taken into consideration that its radioactive constant is $5.88 \times 10^{-8} \times \text{sec}^{-1}$ and that the alpha ray emitted in the course of the disintegration of each atom has the kinetic energy of 0.84×10^{-5} ergs. The energy liberated per second by this quantity of polonium is: $4.6 \times 10^{-13} \times 2.88 \times 10^{21} \times 5.88 \times 10^{-8} \times 0.84 \times 10^{-5} = 6.54 \times 10^{-4}$ ergs. To summarize:

8.6×10^{-11} grams of Ra D liberate	2.3×10^{-5} ergs per second
3.8×10^{-14} grams of Ra E liberate	8.7×10^{-6} ergs per second
4.6×10^{-13} grams of Ra F liberate	65.4×10^{-5} ergs per second
Total	76.4×10^{-5} ergs per second

One microgram of radium anchored in the body produces, with all its products of disintegration, 1.976 ergs per second. The above mentioned quantities of Ra D, Ra E and Ra F (polonium) thus produce an energy corresponding to that emitted by 39×10^{-5} micrograms of radium or to 0.000,000,39 milligram of radium fixed in the body.

It is known that the skeleton and certain other organs of the human body possess a certain very weak radioactivity, due to ingested food and drink. Fernau and Smereker calculate this radioactivity at 1.5×10^{-5}, or 0.000,015 milligram. The amount of long-lived radioactive substances corresponds, therefore, as far as its physical effects are concerned, to a maximum of 2.6 per cent of the natural radioactivity of the human body. We must admit that this radioactive deposit has been formed by the ingestion of an exaggerated quantity of radon. As was demonstrated above, the active deposit which served for comparison was calculated without taking into account the elimination of Ra D, Ra E and Ra F, and this elimination is relatively large. We may then conclude that the daily ingestion of approximately 4,000 millimicrocuries, in the course of a year will not, in the long run, have any harmful effects.

These theoretical deductions, as stated above, are confirmed by long empirical experience at radioactive spas. Disagreeable or toxic effects of radioactivity have never been observed among the natives or the employees of such spas who have been exposed without taking any precautions, to the inhalation of considerable quantities of radon for years.

IX. CONCENTRATION OF RADON TOLERATED BY THE BODY

Investigations in the sphere of industrial hygiene allow us to approach the question from another angle. Barker[1] calculated that workers in a factory for luminous watch dials were exposed to an atmosphere containing 5×10^{-11} curies per liter, that is, 500 times the quantity of radon found in ordinary air. Let us grant that the constant presence in the body of 3,600 milliliters of air corresponds to 4×10^{-8} milligrams of radium. The human body contains, according to what was stated above, 1.5×10^{-5} milligrams of radium. The radiation of radon will therefore be at the rate of 0.3 per cent of the radiation due to natural radioactivity of the body. Therefore, according to Barker, any toxic effects in these work-

ers, by ingestion of radon, are inconceivable.

In a similar study on the radon content of the air in radium laboratories, Read and Mottram[14] admit that the "tolerance concentration" for radon is approximately 10^{-11} curie per cubic centimeter, or 10^{-8} curie per liter.

The air in the Joachimsthal mines contains 2×10^{-12} to 6×10^{-12}, sometimes even 2×10^{-11} curie per cubic centimeter. Nevertheless, the pulmonary carcinoma observed in the workmen of these mines is attributed by these authors to the chromium and arsenic in the dust of the atmosphere. Moreover, as Humphris[10] remarks, radioactive dusts may be deposited in the lungs as a result of employing electric drills. Tschelnitz[16] believes that in addition to the dust of radioactive substances, quartz dust may also be a very important factor in the development of lung cancers. Flinn[6] asks whether, in such concentrations, radon may not produce some deleterious effect in men working all year and for many years in this atmosphere. At present it seems that this question can be answered only negatively.

X. DOSAGE USED IN TREATMENT

We are now in a position to approach the important question of dosage of radon. The calculations of Hirschi[8] and of Fernau and Smereker[4] have shown that the energy produced by the long-lived active deposit following the ingestion on an average of 1,460,000 millimicrocuries in the course of a year is at the rate of 2.6 per cent of that produced by the natural radioactivity of the body. Such a change in the normal radioactivity is certainly too slight to explain any toxic effect whatever. On the other hand, according to the previously mentioned authors Flinn,[5] Hirschi and Bodmer,[9] as well as Rajewsky,[13] 1 microgram and, in certain cases, even a fraction of a microgram anchored in the organism should be considered as the limit beyond which a deposit may become dangerous. It is preferable to fix this limit at 0.01 microgram in order to be on the safe side as far as calculations are concerned. The natural radioactivity of the body being 1.5×10^{-5} milligram, this deposit is about seven-tenths of that amount.

Speaking of radon, we can conclude that its ingestion should be considered as harmless as long as the radioactive deposit in the body formed thereby does not exceed an equivalent of 0.01 microgram of radium. In other words, an internal radon treatment should not be pursued above the limit dose which produces a radioactive deposit liberating in each second an energy more than 70 per cent of the natural radioactivity of the body.

An average of 1,460,000 millimicrocuries of radon ingested in the course of one year produces, as stated above, 2.6 per cent of the natural radioactivity of the body. Thus 70 per cent of the radioactivity would be produced by 27 times that amount—that is, by about 40,000,000 millimicrocuries or 40 millicuries of radon. This dose has been established without taking into account the elimination of Ra D, Ra E and Ra F (polonium); nevertheless, it would not be wise to exceed this maximum amount in treatment.

Accordingly, doses of 500 to 1,000 millimicrocuries per dose and of several thousand millimicrocuries per day may be considered far below the toxic dose. On the other hand, doses as high as 300,000 millimicrocuries per day, as recommended by some German authors, may probably be too high.

XI. CONCLUSION

A new method of "mild" radon application in therapy has been described and the limit of dosage for such internal radon treatment has been calculated. This maximum dosage has been found to be 40,000,000 millimicrocuries or 40 millicuries of radon in the course of one year.

REFERENCES

1. Barker, H. H. Radon ingestion and its possible health dangers. Am. J. Roentgnol. & Rad. Therapy, 1934, *31*, 673–675.

2. DECHAUME, M. Nécrose des maxillaires consécutives à la curiethérapie interne. *Rev. de stomatol.*, 1937, *39*, 89–106.
3. DUVOIR and LAYANI, F. La thoriumthérapie dans des rhumatismes. *Rev. du rhumatisme*, 1937, *4*, 936.
4. FERNAU, A., and SMEREKER, H. Ueber das Verbleiben radioaktiver Substanz im Organismus bei Radium-Emanationstrinkkuren. *Strahlentherapie*, 1933, *46*, 365–373.
5. FLINN, F. B. Dangers of internal radium therapy. *Am. J. Phys. Therapy*, 1932, *9*, 65–70.
6. FLINN, F. B. Radium salts and emanation. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 830–836.
7. HAPPEL, P. Zur Frage der Radiumschwachtherapie. *Fortschr. d. Therap.*, 1933, *9*, 353–362.
8. HIRSCHI, H. Die Bedeutung der radioaktiven Strahlung für Balneologie und Klimatologie. *Schweiz. med. Wchnschr.*, 1938, *68*, 403–404.
9. HIRSCHI, H., and BODMER, H. Therapie mit radioaktiver Emanation; Für und Wider, Dosierung, Missverständnisse. *Schweiz. med. Wchnschr.*, 1938, *68*, 404–407.
10. HUMPHRIS, F. H. Mild radium therapy. *Brit. M. J.*, 1936, *2*, 532–535.
11. KLINGHOFFER, S. Dispositif pour rendre constante la teneur du milieu en radon au cours d'expériences biologiques prolongées. *Compt. rend. Soc. de biol.*, 1938, *128*, 661–663.
12. MEYER, S. Physikalische Grundlagen von Emanationskuren. *Strahlentherapie*, 1937, *58*, 656–663.
13. RAJEWSKY, B. Researches in the problem of radium poisoning and tolerance dose of radium. *Radiology*, 1939, *32*, 57–62.
14. READ, J., and MOTTRAM, J. C. "Tolerance concentration" of radon in the atmosphere. *Brit. J. Radiol.*, 1939, *12*, 54–60.
15. RUTHERFORD, ERNST, and others. Radiations from Radioactive Substances. Cambridge University Press, London, 1930, pp. 398, 403, 404.
16. TSCHELNITZ, H. Physikalische Bemerkungen zur Atiologie des St. Joachimsthaler Lungenkarzinoms. *Strahlentherapie*, 1935, *53*, 269–275.
17. WEIL, M. P. *Rev. du rhumatisme*, 1937, *4*, 915.

EFFECT OF ROENTGEN IRRADIATION ON CAPILLARY PERMEABILITY AND INFLAMMATION IN THE SKIN OF THE RABBIT*

By R. H. RIGDON *and* HOWARD CURL
Departments of Pathology and Anatomy, University of Tennessee
MEMPHIS, TENNESSEE

ONE of us has been interested in an experimental study of capillary permeability and inflammation in the skin of the rabbit.[10,11,12] In these studies, trypan blue is injected intravenously and the time and the quantity of the dye that localizes and concentrates in the areas of inflammation are observed. Histological preparations of the skin are made to study the type and the rate of development of the inflammatory reaction. It has already been shown by this technique that trypan blue localizes and concentrates in areas of inflammation in the skin of the rabbit only during a specific interval following either the application of xylol or the intradermal injection of other irritants. There is a progressive diminution in the intensity of the staining of the xylol treated areas of skin when xylol is applied at varying intervals preceding the intravenous injection of this dye. When xylol is applied to the skin three hours or longer before the dye is injected, essentially the same amount of dye localizes and concentrates in the areas of inflammation as in the untreated skin of the same rabbit. The greatest amount of dye localizes and concentrates in the areas of skin where xylol is applied immediately preceding the intravenous injection of the dye. It becomes obvious from these experimental studies therefore that the localization and the concentration of trypan blue is not dependent upon the presence of hyperemia and edema.

Polymorphonuclear leukocytes begin to appear in the extravascular tissues in the xylol treated areas of skin approximately two hours following the application of the irritant. The quantity of trypan blue that localizes and concentrates in an area of skin where xylol is applied two hours preceding the injection of the dye is much less than that which localizes and concentrates in an area of skin where xylol is applied immediately preceding the injection of the dye. It is obvious, therefore, that the time in which trypan blue localizes and concentrates in an area of inflammation produced by xylol is different from the time in which polymorphonuclear leukocytes begin to appear in the tissues. Furthermore, at the time the greatest number of leukocytes are present trypan blue fails to concentrate in the xylol treated areas of skin.

It has been suggested that following an intravenous injection of trypan blue the dye localizes and concentrates in an area of inflammation as a result of a change in the permeability of the cells.[12] The interval in which this permeability is increased over that of the normal cells is influenced by both the type of irritant and the degree of injury. The greatest degree of injury apparently occurs immediately following the application of xylol to the skin. The injured cells return to normal within a period of approximately three hours as indicated by the quantity of dye that localizes and concentrates in the area at this time.

This paper is a report of our observations on the localization and the concentration of trypan blue, following an intravenous injection, in local areas of the rabbit's skin treated with roentgen rays. It also includes a description of the pathological changes in these areas of skin. In subsequent publications one of us will report the results of similar experiments in which ultraviolet and infra-red rays are used rather than the roentgen rays.

* Aided by a Grant from the International Cancer Research Foundation.

METHODS AND MATERIALS

Adult rabbits are used. The skin over the sides and the abdomen is carefully shaven twenty-four hours or longer before the experiment begins. Local areas of skin are treated with roentgen rays at varying intervals before 10 to 15 cc. of a 0.2 per cent saline solution of trypan blue is injected into the marginal vein of the ear. Observations are made on the areas of irradiated skin that become blue. The time of the appearance of the dye in these areas is also recorded.

The apparatus used for irradiating the skin is a Wantz Jr. transformer with a milliamperage controlled by a General Electric Kersley filament stabilizer. The rabbits are covered with a sheet of lead in which there is a window 15 mm. in diameter. The following factors are used in the treatment of the majority of the animals: 86 kv. (peak), 5 ma., 7½ min., 20 cm. target-skin distance, no filter. In the experiments the length of the exposure is either 2½ minutes, 5 minutes, 7½ minutes or 10 minutes. The machine delivers 272 r per minute. The doses are as follows: 680 r, 1,360 r, 2,040 r and 2,720 r.

The irradiated portions of skin in some of the rabbits are removed at varying intervals and fixed immediately in a 10 per cent solution of formalin. Sections are prepared and stained with hematoxylin and eosin.

EXPERIMENTAL

Localization and Concentration of Trypan Blue in Areas of the Skin Irradiated with Roentgen Rays.

In this experiment 24 rabbits were used. A few of these animals were irradiated for varying intervals with different quantities of radiation. The time at which the skin was irradiated before the dye was injected is shown in Table 1. The irradiated areas of skin became blue within a period of five to thirty minutes following the intravenous injection of trypan blue. The intensity of the staining varies in the different areas of the same rabbits and also in the different animals. The dye localizes and concentrates more frequently in the areas of skin irradiated sixty minutes preceding the injection of the dye than in any of the other irradiated areas.

A second group of 14 rabbits were treated with roentgen rays (86 kv. peak, 5 ma., 7½ min. at 20 cm. target-skin distance) over local areas of the skin at varying intervals before the dye was injected. The technique used on these rabbits was the same as that in the experiment discussed above except that the last area of skin was treated immediately following the injection of the trypan blue. The results of the localization and the concentration of the dye in this group of rabbits is shown in Table II. The dye localizes and concentrates in 7 of the 14 areas irradiated immediately following the injection of the dye. The dye localizes and concentrates in each of the 14 irradiated areas when the trypan blue is injected one hour following the irradiation. This dye does not concentrate in either of the 20 areas irradiated from two to twenty-one hours before the dye is injected.

The composite data in this experiment (Table III) show that the dye localizes and concentrates only 6 times in 29 observations when the interval between the irradiation and the injection of the dye is thirty minutes; 35 times out of 46 observations when the interval is sixty minutes; 3 times out of 30 observations when the interval is two hours; 0 times out of 58 observations when the interval is from three to twenty-one hours.

The following protocol (rabbit No. 995) illustrates this localization and concentration of trypan blue in the skin of the rabbit following irradiation. The dose is 86 kv. (peak) with no filter, 2,040 r at the rate of 272 r per minute.

1:00 P.M. Skin irradiated in Area 1
2:00 P.M. Skin irradiated in Area 2
2:00 P.M. Skin irradiated in Area 3
3:30 P.M. Skin irradiated in Area 4
4:00 P.M. 10 cc. of trypan blue given intravenously
4:05 P.M. Skin irradiated in Area 5
4:13 P.M. Trypan blue in Area 5
4:45 P.M. The skin in Areas 5 and 3 are blue. The largest amount of dye is in Area 5. Areas 1, 2 and 4 do not show any more dye than there is in the untreated skin.

Pathological Lesions in the Skin of Rabbits Following Recent Irradiation with Roentgen Rays.

Twenty of the rabbits used in the experiment to study the localization and concentration of trypan blue were killed. The irradiated areas of skin were studied histologically. The observations recorded below are based upon the study of 48 sections of skin removed at the following intervals after seven and a half minutes of irradiation: immediately, 5; thirty minutes, 10; sixty minutes, 5; ninety minutes, 5; two hours, 10; three hours, 5; four hours, 3; eighteen hours, 12.

Polymorphonuclear leukocytes are present in

TABLE I

LOCALIZATION AND CONCENTRATION OF TRYPAN BLUE IN AREAS OF SKIN IRRADIATED WITH ROENTGEN RAY*

Rabbit No.	Interval Between the Irradiation of Skin and Injection of Dye									
	7 hr.	6 hr.	5 hr.	4 hr.	3 hr.	2 hr.	1.5 hr.	1 hr.	30 min.	0 min.
86 kv. (peak), 5 ma., 10 min. at 20 cm. target-skin distance (2,720 r)										
677	–	–	–	–	o	o	–	+	–	o
678	–	–	–	–	o	o	–	+	–	o
680	–	–	–	–	o	o	–	+	–	o
86 kv. (peak), 5 ma., 7½ min. at 20 cm. target-skin distance (2,040 r)										
652	–	–	–	o	o	o	–	+	–	o
653	–	–	–	o	o	o	–	+	–	o
654	–	–	–	o	o	o	–	o	–	+
655	–	–	–	o	o	o	–	+	–	o
922	–	–	–	–	o	o	–	+	–	o
923	–	–	–	–	o	o	–	+	–	o
924	–	–	–	–	o	o	–	o	–	o
925	–	–	–	–	o	o	–	+	–	o
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	+	–
X-4	–	–	–	–	–	–	–	+	+	–
X-5	–	–	–	–	–	o	o	o	o	o
X-6	–	–	–	–	–	o	o	+	o	o
X-7	–	–	–	–	–	o	o	+	o	o
86 kv. (peak), 5 ma., 5 min. at 20 cm. target-skin distance (1,360 r)										
630	o	o	o	o	o	+	–	+	–	o
631	o	o	o	o	o	+	–	+	–	o
632	o	o	o	o	o	+	–	+	–	o
633	o	o	o	o	o	o	–	?	–	o
634	o	o	o	o	o	?	–	+	–	o
635	o	o	o	o	o	?	–	o	–	o
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	o	–
X-4	–	–	–	–	–	–	–	+	o	–
86 kv. (peak), 5 ma., 2½ min. at 20 cm. target-skin distance (680 r)										
X-1	–	–	–	–	–	–	–	o	o	–
X-2	–	–	–	–	–	–	–	o	o	–
X-3	–	–	–	–	–	–	–	+	+	–
X-4	–	–	–	–	–	–	–	+	+	–

*=272 r per minute.
+=Dye present in area irradiated.
o=No dye present in area irradiated.
–=No irradiation applied.

TABLE II

LOCALIZATION AND CONCENTRATION OF TRYPAN BLUE IN IRRADIATED AREAS OF RABBITS' SKIN

Rabbit No.	Interval Between the Irradiation of Skin and Injection of Dye						
	21 hr.	18 hr.	3 hr.	2 hr.	1 hr.	30 min.	0 min.
995	−	−	0	0	+	0	+
996	−	−	0	0	+	0	+
997	−	−	0	0	+	0	+
1002	0	−	−	0	+	0	+
1003	0	−	−	0	+	0	0
1024	−	0	−	0	+	0	0
1025	−	0	−	0	+	0	0
1026	−	0	−	0	+	0	+
1031	−	0	−	0	+	0	0
1033	−	0	−	0	+	0	0
1078	−	−	−	−	+	+	+
1079	−	−	−	−	+	0	0
1080	−	−	−	−	+	0	0
1081	−	−	−	−	+	+	+
Total Observations	2	5	3	10	14	14	14
+	0	0	0	0	14	2	7
−	2	5	3	10	0	12	7

* The dye was injected immediately before the last area of skin was irradiated.

+ = Dye present; 0 = No dye; − = No irradiation.

The skin of these rabbits was irradiated for 7½ minutes, 86 kv. (peak), 5 ma. at 20 cm. target-skin distance (2,040 r at the rate of 272 r per minute).

the corium within an hour following irradiation (Fig. 1). The number of these cells apparently increase during the next three to four hours. These leukocytes infiltrated not only the corium but in some of the rabbits they were present in the cutaneous maximum muscle. The lumen of the small blood vessels was filled with leukocytes and large numbers of these cells surrounded the vessels. Eighteen hours following this irradiation there were fewer leukocytes present in the corium than during the first four hours.

The nuclei of the connective tissue cells in the corium are frequently swollen and apparently stain more deeply with hematoxylin than the cells in the untreated areas of skin. Vacuoles are present in the cytoplasm of some of these cells. There are no pathological changes observed in the endothelial cells of the small blood vessels. It is rare to find a pyknotic cell in the epidermis within a period of eighteen hours following irradiation. Four sections removed from one rabbit six days following the irradiation show a few pyknotic cells in the

TABLE III

INTERVAL IN WHICH TRYPAN BLUE LOCALIZES AND CONCENTRATES IN AREAS OF IRRADIATED SKIN*

Interval†	Localization of Trypan Blue			Total Number of Observations
	Positive	Negative	Questionable	
0 min.	8	26	0	34
30 min.	6	23	0	29
60 min.	35	10	1	46
90 min.	0	3	0	3
2 hr.	3	25	2	30
3 hr.	0	23	0	23
4 hr.	0	10	0	10
5 hr.	0	6	0	6
6 hr.	0	6	0	6
7 hr.	0	6	0	6
18 hr.	0	5	0	5
21 hr.	0	2	0	2

* These data include all irradiated areas irrespective of the length of time of the exposure.

† Time between the irradiation of the skin and the intravenous injection of trypan blue.

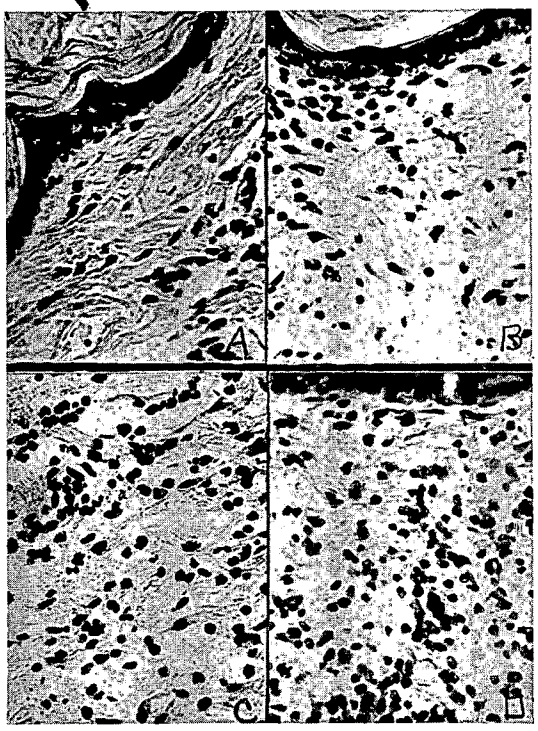


FIG. 1. Rabbit No. 923. Polymorphonuclear leukocytes infiltrate the corium following roentgen irradiation (86 kv., peak, 5 ma., 7½ min. at 20 cm. target-skin distance). Note the increase in number of leukocytes during the first three hours following irradiation. There are essentially no leukocytes in the corium (*A*) thirty minutes after the area was irradiated. This rabbit was given 2,040 r at the rate of 272 r per minute. *B*, section removed sixty minutes after irradiation; *C*, section removed two hours after irradiation; *D*, section removed three hours after irradiation.

epidermis. The nuclei of the connective tissue cells in the corium appear more compact than normal and also appear to stain more deeply with hematoxylin. The cells in the epidermis do not show any evidence of hyperplasia six days following irradiation.

DISCUSSION

These experiments show that trypan blue, following an intravenous injection, localizes and concentrates in areas of the rabbits' skin treated with roentgen rays only during specific intervals. Trypan blue localizes and concentrates in the skin when it is injected either immediately before or immediately after the area is irradiated. This dye also localizes and concentrates in areas of skin irradiated one hour previous to the injection of the dye. There is an interval, therefore, between immediately and one hour and after two hours in which trypan blue does not localize and concentrate in areas of skin even in the same rabbit treated with the same amount of radiation. The dye frequently localizes within thirty minutes and usually within a period of ten minutes after it is injected intravenously.

The frequency with which the dye localizes and concentrates in the areas, irradiated an hour before the dye is injected, is greater than that occurring in the areas irradiated either immediately before or immediately after the injection of the dye. It appears that the frequency with which this reaction occurs in irradiated areas of skin is significant. The observation that this colloidal dye, following an intravenous injection, localizes and concentrates in the skin indicates that the permeability of the cells in the skin of the rabbit is affected immediately by irradiation. Variations in the permeability of the cells following irradiation is discussed in a review by Warren.[3] It appears, however, from Warren's work that the demonstration of the time in which these changes in permeability appear in our studies is much earlier than those of other investigators.

This demonstration of a localization and a concentration of trypan blue in areas of skin irradiated either immediately before, immediately afterwards or during the time of irradiation is interesting in view of MacKee's[6] recent statement that "except in the case of very intense irradiation, no immediate effect is observed in the cell. After a longer or shorter period changes begin to take place." The quantity of radiation used in these experiments is of course large as compared with that used in humans; however, the macroscopic changes in the skin of the rabbit are minimal.

It is well known that there is an increase in hydrogen ion concentration following irradiation. This may be very transitory in some tissues.[6] Physiological changes in cells

have been explained by electrons ionizing atoms that may be in their path.

The ionized atom is temporarily in an abnormal condition, and while in this state, it lends itself readily to entering into new combinations. Ionization of the individual atom lasts only a very short time. If, however, enough of them are ionized simultaneously, a large enough percentage of the cell constituents may undergo transformation so that an apparent change is produced.[6]

It is interesting to observe an interval of one hour in which trypan blue fails to localize and to concentrate in irradiated areas of skin. It has been suggested in other studies that this dye localizes and concentrates in the skin as a result of a change in the metabolism of the cells.[12] This disturbance in the metabolism of the cell apparently may occur in the cells of the skin immediately following irradiation and it remains for only a very short period as indicated by the localization and concentration of trypan blue. One hour later a second reaction occurs in the cells which permits the localization and the concentration of the dye. This second reaction likewise remains only during a short interval as indicated by the failure of trypan blue to localize and to concentrate in areas of skin irradiated three hours or longer before the dye is injected.

The immediate change that occurs in the skin of the rabbit may be explained by the phenomena discussed above. The mechanism of the localization and concentration of trypan blue in areas of skin irradiated one hour previously apparently may result also from a disturbance in the metabolism of the cells, however, this is the result of a delayed reaction of the irradiation on the cell.

Rudisill and Hoch[14] in 1938 made some interesting observations on the mechanism of the effect of roentgen irradiation on cells. These investigators assumed that the respiration of the cell (respiration as used here signifies all the energy yielding reactions of the cell) could be injured by irradiation.

Cellular respiration is carried on through reduction-oxidation reactions. . . . cellular damage resulting from x-rays shows a latent period and autocatalytic reactions likewise exhibit a preliminary lag phase. . . . it seems logical to assume that the autocatalytic mechanisms governing the redox [reduction-oxidation reactions] equilibria are affected by x-rays.

The effect of roentgen irradiation on the redox system was studied by determining the time necessary for the reappearance of the cytochrome C absorption band in the visible spectrum following oxygenation. Yeast cells were used for this study.

. . . the cytochrome C band did not reappear after oxygenation until from three and three-fourths to five and one-half minutes had elapsed, an average initial increase of 225 per cent. This we interpret as signifying definite although not irreparable damage to the dehydrogenase complex. This transitory nature of this effect indicates the ability of the injured cells to recover and but serves to emphasize the fundamental protoplasmic property of repair in the living organism. . . . the biological effects of x-rays on cells may result from inactivation or destruction of cell respiratory mechanisms through the effects of these substances on the co-catalysts of the dehydrogenases.

The ability of an irradiated cell to recover from sub-lethal exposure to x-rays is to be found in its ability to elaborate more catalyst to replace that which was inactivated, and to do it rapidly enough to meet its own particular respiratory requirements.

The delayed lethal action of x-rays on cells (latent period) finds explanation in the fact that the reaction chain involved contains autocatalysts. (Rudisill and Hoch[14].)

The observations, as recorded in the present experiment on the time that trypan blue localizes and concentrates in areas of rabbit's skin, indicate that the effect of the irradiation may be manifest within a period of only a very few minutes. This biological effect like that observed by Rudisill and Hoch in yeast occurs immediately and is transient. This apparently is an indication of the ability of the cells in the skin of the rabbit to recover rapidly from the injury produced by this amount of radiation.

Several recent observers have reviewed and discussed the effect of irradiation on the skin.[2,3,8] There appears to be some variation in the effect of irradiation on this tissue especially with regard to the cellular reactions and the mechanism of the action of irradiation on inflammation. The most conspicuous variation from the normal observed in this experiment is the presence of polymorphonuclear leukocytes in the corium. These cells are present in the tissues after approximately sixty minutes. They usually increase in number during the following five hours. The rapidity with which polymorphonuclear leukocytes concentrate in the corium following irradiation is interesting when one considers the possible mode of action of roentgen rays on acute local infections. The significant rôle of the polymorphonuclear leukocytes in the phagocytosis of certain bacteria is well established. A rapid concentration of leukocytes about foci of bacteria apparently will permit an increase in the rate of phagocytosis of the bacteria and probably permit a more rapid localization and destruction of the organisms.

The absence of any histological changes in the epithelial cells and blood vessels in the corium of these animals may be accounted for by the short interval between the time of irradiation and the time in which the sections are removed. Rottmann[13] states that,

> Changes demonstrable microscopically can be found in the skin of subjects a few hours after the irradiation when borderline erythema is barely beginning macroscopically. . . . The changes in the epidermis consist of edema of the cells and nuclei, vacuolization and contraction of the nuclei. There were granular changes in the stratum granulosum which on giving three erythema doses could also be seen in spots in the upper cell layers. There were always vessel changes in the corium: swelling of the endothelium, great changes in the adventitia cells, perivascular cell infiltration, chiefly lymphocytes, fewer leucocytes.

Pohle and Bunting[9] have described in detail the histological changes occurring in the skin of rats, beginning twenty-four hours after irradiation.

There is no relation, as far as we have determined, between the time that trypan blue localizes and concentrates in areas of skin treated with 2,040 r at the rate of 272 r per minute (86 kv., peak, with no filter), and the time in which polymorphonuclear leukocytes localize in the same area. In previous studies on capillary permeability and inflammation one of us also has failed to demonstrate a correlation between these two phenomena.[12]

It has been suggested that an increase in capillary permeability occurs in areas of inflammation as a result of a disturbance in the ratio of calcium, phosphorus and potassium in the cell.[12] Adler and Adler[1] think that there is a fall in the calcium and potassium content of the skin with an increasing dose of roentgen rays. Lieber[5] has expressed the opinion that a disturbance in the physiochemical equilibrium of potassium and calcium is enough to account for a disturbed function in the affected cells. Henschen and Becker's[4] observation that irradiation produces an alkalosis in the treated skin may be a significant finding in view of Menkin's[7] demonstration that the type of cells occurring in areas of inflammation is determined by the hydrogen ion concentration. Polymorphonuclear leukocytes are found in alkaline environment and lymphocytes occur more frequently in an acid medium.

SUMMARY

A change occurs in the skin of the rabbit immediately following irradiation with roentgen rays as shown by the localization and the concentration of trypan blue following an intravenous injection of the dye. The time is brief during which this dye localizes and concentrates in these areas. It is suggested that this localization and concentration of dye results from a change in the permeability of the cells as produced by the irradiation. Areas of skin treated with a similar quantity of radiation one hour previously likewise become blue fol-

lowing the injection of the dye. Areas of skin treated with the same amount of radiation three hours or longer before the dye is injected do not show any more dye than the untreated areas of skin.

Polymorphonuclear leukocytes are present in the corium of the irradiated skin after approximately sixty minutes. The number of these cells increases during the following several hours. There is no correlation between the time in which trypan blue localizes and concentrates in areas of irradiated skin and the time in which polymorphonuclear leukocytes infiltrate the corium in the same area.

The mechanism for the increase in capillary permeability following irradiation is discussed.

REFERENCES

1. Adler, K., and Adler, Margarethe. Calcium und Kaliumstoffwechsel unter den Einfluss der Röntgenstrahlen bei Kaninchen. *Strahlentherapie*, 1932, *44*, 481–488. Abs. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 284.
2. Desjardins, A. U. Radiotherapy for inflammatory conditions. *J. Am. M. Ass.*, 1941, *116*, 225–231.
3. Duggar, Benjamin M., Editor. Biological Effects of Radiation. Vol. 1, Chap. xiv, p. 473. McGraw-Hill Book Co., New York, 1936.
4. Henschen, C., and Becker, F. Röntgenbestrahlung der akuten, der subakuten und der chronischen Phlebitis und Thrombophlebitis. *Schweiz. med. Wchnschr.*, 1937, *67*, 438.
5. Lieber, G. D. Physico-chemical action of roentgen rays on the organism. III. *Strahlentherapie*, 1925, *20*, 93–102. Abs. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 503.
6. MacKee, George M. X-Rays and Radium in the Treatment of Diseases of the Skin. Third edition. Lea & Febiger, Philadelphia, 1938.
7. Menkin, Valy. Dynamics of Inflammation. Macmillan Co., New York, 1940.
8. Pendergrass, E. P., and Hodes, P. J. Roentgen irradiation in the treatment of inflammations. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 74–106.
9. Pohle, E. A., and Bunting, C. H. Skin reactions following exposure to roentgen rays; comparison of effect of two different wave lengths on skin of rats. *Radiology*, 1929, *13*, 496–503.
10. Rigdon, R. H. Capillary permeability in areas of inflammation produced by xylene. *Arch. Surg.*, 1940, *41*, 101–109.
11. Rigdon, R. H. Observations on capillary permeability in areas of inflammation produced by Staphylococci. *Surgery*, 1941, *9*, 436–442.
12. Rigdon, R. H. Relation of capillary permeability to inflammation. *South. M. J.*, 1941, *34*, 292–295.
13. Rottmann, H. G. Histology of borderline ray erythema. *Strahlentherapie*, 1927, *27*, 518–532. Abs. Am. J. Roentgenol. & Rad. Therapy, 1929, *21*, 199.
14. Rudisill, Hillyer, Jr., and Hoch, J. H. How x-rays may kill cells. *Radiology*, 1938, *31*, 104–106.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR
Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, to be announced.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary,* E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, to be announced.

Vol. 49, No. 2

EDITORIAL

ROENTGENOLOGIC EXAMINATION AND, NOT OR, GASTROSCOPY*

ALMOST every diagnostic procedure of major importance that has passed its initial tests follows a familiar cycle. At first the new method is accredited both with capabilities and with limitations that it does not possess, for its enthusiastic proponents are inclined to imagine vain things, and practitioners of the old ways are prone to regard the new with extreme doubt. Neither attitude is unnatural or blameworthy, for imagination is essential to progress, and, on the other hand, without a healthy degree of skepticism real progress often would suffer from imposture. Not rarely, however, the rivalry between believers and doubters degenerates into an academic hostility that is both foolish and futile. Whether this occurs or not, the new procedure continues in its cycle of evolution and eventually finds its proper place. Usually it fails to fulfill the extravagant expectations of its early advocates, but often it proves eventually to be remarkably efficient in ways that had not been foreseen. Occasionally it supersedes, but far more often it supplements, an older test, so that old controversies arising from fancied competition usually are made to appear ridiculous. In short, the final status of the method is determined, not by early impressions and predictions, but by the results of long and thorough trial.

Many of you here today witnessed the transit of the roentgenologic method through a cycle of this sort. At the beginning its immediate capabilities were greatly overestimated, for it was rather widely supposed that the diagnosis of virtually all internal diseases would soon be effected by simple roentgenoscopy and roentgenography. Disappointment followed, of course, and only after many years did the roentgenologic diagnosis of internal disease in general and of abdominal affections in particular become really efficient. Then it seemed for a time that other methods of investigation might be supplanted, but although the scope and reliability of roentgenologic diagnosis have continued to increase, the anamnesis, physical examination and laboratory tests have not been discarded or even curtailed.

That gastroscopy is following a comparable pattern is rather obvious. The procedure has matured sufficiently to be adopted into the medical armamentarium but is still young enough that estimates of its value are bound to vary. I am willing to offer a brief appraisal and even to compare certain merits of gastroscopy with those of roentgenologic examination, but only with the understanding that my opinions are based solely on present common achievements by both procedures and not on extraordinary accomplishments or future potentialities of either method.

Sometimes superiority of either gastroscopy or roentgenologic examination is claimed on the ground that in specific instances one method disclosed a lesion which the other had failed to reveal. That kind of comparison is insidious and unfair, for, aside from disease in certain areas of the stomach that are not accessible to gastroscopic inspection, any gastric lesion that would be visible macroscopically should be found by either method, and all failures should be charged to the examiner and not to the mode of examination. If gastroscopy must be compared with roentgenologic ex-

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

amination, there are, I think, at least two particulars in which gastroscopy excels: namely, in establishing diagnoses of gastritis and in determining decisively whether or not gastric ulcers have healed or are in process of healing.

In Europe before the outbreak of the present war, considerable advances had been made in the roentgenologic diagnosis of gastritis, and a few roentgenologists had become proficient in identifying the disease. In this country, it seems to me, progress in the recognition of gastritis has been slow, perhaps partly because of lingering uncertainties as to the pathology, varieties, clinical significance and distinguishing marks of the disease. Ulcerative gastritis can be identified definitely, and frequently the signs of hypertrophic gastritis are strongly suggestive but in most cases of the hypertrophic variety and all of the atrophic form the roentgenologic picture is either inconclusive or completely negative, for it may be imitated closely by purely physiologic alteration of the mucosal relief. My gastroscopic colleagues, however, can identify gastritis of any variety almost unerringly, and it is my custom to request their aid in any case in which the existence of the disease seems likely.

It has been claimed by some authors also that the differential diagnosis of benign from malignant ulcer, regardless of the factor of healing, can be made more reliably with the gastroscope than with roentgen rays. I am inclined to doubt this claim, for when malignancy is not roentgenologically evident it is not usually evident on direct macroscopic inspection. But I shall not emphasize this doubt, for I realize that small ulcerating carcinomas, diagnosed roentgenologically as such, often are indistinguishable from simple ulcer on inspection of the excised specimen. Like roentgenologic examination, gastroscopy deals with living tissues, not specimens, and gastroscopy has a further advantage in being able to see lesions in their true color, whereas roentgen rays depict them only in black and white

But roentgenologic examination also has advantages. They are so numerous and so familiar to you that I forbear listing them.

The efficiency of each method keeps both on their toes—each has its advantages but it is not fair to foster the notion that the two methods are competitive and antagonistic. On the contrary, they are complementary and cooperative. It is not a question of roentgenologic examination *or* gastroscopy but of roentgenologic examination *and* gastroscopy in any case in which either method is likely to elicit significant data that the other procedure failed to disclose.

B. R. Kirklin

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, to be announced.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1943, to be announced.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Wiewer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital. Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. Herman Klapproth, Sherman, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secreatry for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

URGENT NEED OF CONSERVING ROENTGEN-RAY EQUIPMENT AND ACCESSORIES

Most civilian radiologists are aware that it is becoming increasingly difficult to obtain roentgen-ray accessories, but the gravity of the situation and the necessity of taking steps to meet it are not fully appreciated. Among items in which the shortage is already severe or threatens to become so are: cassettes, intensifying screens, developing hangers, developing tanks, roentgen tubes, roentgen-ray meters and film driers. Most critical is the scarcity of developing hangers, which are almost unobtainable, and of intensifying screens.

Chief among causes of the condition is, of course, the tremendous demands of our armed forces. Priorities have vastly reduced available stocks of essential materials, notably steel and especially stainless steel. To this circumstance is added the fact that many of the skilled artisans who are indispensable for the manufacture of roentgenologic apparatus have been inducted into the armed services, and production is correspondingly diminished.

It seems unlikely that the condition will be relieved soon or in substantial degree by governmental action, for the government must place the welfare of its fighting men above all other considerations, and all of us heartily approve of that obligation. As radiologists we must make the best of the situation by conserving the equipment we have and using it wherever it is most needed. Our past prodigality has left a wide margin for retrenchment and economy without serious loss of efficiency. Damaged equipment can be repaired. Outmoded accessories can be redeemed from private junk heaps and used again if needed. All apparatus can be handled with greater care and used only when really necessary. Equipment left behind by physicians who have joined the armed forces can be sold or loaned to civilian radiologists and put into useful service. These are only a few of the measures that we can employ, and, if we apply ourselves earnestly to this task, we can accomplish much by efforts and sacrifices that will be very small in comparison with those made by our fighting kinsmen and colleagues.

Military Committee
A. C. Christie, *Chairman*
W. Edward Chamberlain
E. P. Pendergrass
U. V. Portmann
B. R. Kirklin, *Secretary*

SCIENCE BUILDING NAMED IN HONOR OF DR. PFAHLER

During Founders' Day Convocation, on October 13, 1942, at Ursinus College, Collegeville, Pennsylvania, the beautiful new science building was named the Pfahler Hall of Science in honor of Dr. George E. Pfahler, a pioneer radiologist, who has devoted his professional life to the use of roentgen rays and radium in medicine and whose attainments are well known to all radiologists. He has been a member of the Board of Directors of Ursinus College since 1935. A portrait of Dr. Pfahler was unveiled during these special exercises and was presented to the College by Mrs. Pfahler. It is the work of Mr. Robert Susan and hangs in the foyer of the Pfahler Hall of Science. The principal address during the exercises was given by Dr. William D. Coolidge, Vice-President and Director of Research for the General Electric Company of Schenectady, New York, the title being "The Rôle of Science Institutions in our Civilization."

THE RADIOLOGICAL RESEARCH LABORATORY OF COLUMBIA UNIVERSITY

The establishment of a Radiological Research Laboratory in connection with the cancer research program of Columbia University is announced by Dr. Willard C. Rappleye, dean of the faculty of medicine. Dr. Rappleye said:

The research in the laboratory will be mainly concerned with the study of the effect of radiation on living cells and the possibilities of altering resistance to radiation and to the introduction of chemical and

endocrine substances that might conceivably have some bearing on the problem of cancer.

Special attention will be given to setting up a satisfactory program of deep therapy treatment in which high voltage x-rays are used to penetrate deeply into the tissues and destroy cancer. A million volt therapy machine will be installed in the Presbyterian Hospital in connection with the plan.

In addition to research in radiology, experiments will be carried on in the fields of chemistry, immunology, endocrinology and biology. The program represents an effort to develop real authorities on cancer, of whom there are very few. Research will go beyond the ordinary hospital work and will be more of an experimental nature.

Dr. Gioacchino Failla, physicist at the Memorial Hospital, has been appointed director of the laboratory. Dr. Edith H. Quimby, associate physicist at the Memorial Hospital, and Dr. Titus C. Evans, assistant professor of radiology at the State University of Iowa, will be his associates.—*Science*, Dec. 11, 1942, *96*, 533.

GEORGIA RADIOLOGICAL SOCIETY

The annual meeting of the Georgia Radiological Society was held at Lawson General Hospital, Atlanta, in November, 1942. An excellent program was given. The Orthopedic Department, under Colonel Sloat, presented and illustrated many interesting orthopedic cases. Luncheon was served at the Officers Mess. The afternoon program consisted of a paper on "Malignant Lesions of the Mouth," by Dr. Elliott Scarborough, after which discussion of unusual and interesting case reports was taken up The officers of the Society are: *President*, Dr R. C. Pendergrass, Americus; *Secretary-Treasurer*, Dr. James J. Clark, Atlanta.

VIRGINIA RADIOLOGICAL SOCIETY

At a recent meeting of the Virginia Radiological Society the following officers were elected: *President*, Dr. Wright Clarkson, Petersburg; *Vice-President*, Dr. Clayton W. Eley, Norfolk; *Secretary-Treasurer*, Dr. E. Latané Flanagan, Richmond.

CORRECTION

In a paper by M. T. Koven, Bernard E. Epstein, and Max Kulick, entitled "A device to aid in positioning for lateral roentgenograms of the femoral neck," and published in the October, 1942, issue of the JOURNAL, Vol. 48, pages 554–556, the last sentence in the legend of Figure 1 reads as follows: "Note that the thigh is held in slight external rotation." This should read: "Note that the thigh is held in slight internal rotation."

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

CLINICAL ROENTGENOLOGY OF PREGNANCY. By William Snow, M.D., Director of Radiology, Bronx Hospital; Roentgenologist-in-charge, Harlem Hospital, New York City. Cloth. Price, $4.50. Pp. 178, with 119 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

The use of roentgen rays in pregnancy is not as prevalent as it should be. Almost every roentgenologist admits this and knows it is chiefly because he and his fellow specialists are negligent in giving such service as will create a demand for his assistance. The obstetrician has been skeptical, and rightly so, because information has been meagre and often inaccurate and misleading.

By writing this book, Dr. Snow has contributed much toward the rectification of these conditions. His work is the result of thorough painstaking study of methods used in many cases. Whereas most methods of pelvimetry have been too inaccurate or too complicated and theoretical, the method preferred by Dr. Snow and recommended by him is simple and sufficiently accurate for ordinary use. It is so clearly set forth that there is no excuse for anyone failing to comprehend or apply it.

In addition to presenting an excellent simple system of pelvimetry Dr. Snow's book contains much clinical material enabling the roentgenologist to quickly acquire an insight into the problems of pregnancy and to recognize and solve them intelligently. He does not stop with measurements of the maternal pelvis. His methods enable a reasonably accurate determination of height and weight of the fetus and the size of the fetal head, so that invaluable aid can be given in determining the important question of cesarean section. Dr. Snow believes that cases of mental inferiority and many ills of later life could be prevented by timely use of section instead of prolonged labor with undue crushing of the fetal head and excessive anoxemia.

One of the more important features of the work is a group of 22 case reports which show roentgenograms marked and outlined as in actual practice. They are reproduced to scale so that the student may make the actual measurements and work them out for himself if he so desires. Each of the representative cases contains a report chart with measurements, correction factor, true dimensions, and remarks. Data are given for the inlet, mid pelvis, and outlet, and include estimated age and weight of the fetus.

A well illustrated chapter on soft tissue demonstration contains some very interesting cases and should be inspirational to roentgenologists who have been doing less than their best to aid the clinician. The author's tables simplify the calculations greatly. No matter what method of pelvimetry the roentgenologist is accustomed to use, this work can hardly fail to broaden his scope and be of much practical value to him.

E. WALTER HALL

ROENTGEN TREATMENT OF INFECTIONS. By James F. Kelly, M.D., F.A.C.R., Professor and Director of the Department of Radiology, Creighton University School of Medicine; Attending Radiologist, Creighton Memorial St. Joseph's Hospital, St. Catherine's Hospital and Douglas County Hospital, Omaha, and Mercy Hospital, Council Bluffs, Iowa. With the Collaboration of D. Arnold Dowell, M.D., Assistant Professor of Radiology, Creighton University School of Medicine, etc. Cloth. Price, $6.00. Pp. 432, with 122 illustrations. Chicago: The Year Book Publishers, Inc., 1942.

Although this volume surveys the whole field of radiation therapy in infectious diseases, the largest section, comprising 130 pages, is devoted to an exhaustive review of the etiology, pathology and treatment of gas gangrene. Separate chapters deal with peritonitis, acute abdominal infections and pneumonia, and the other infections for which roentgen therapy is now accepted as a procedure of unquestioned value receive rather scant attention. A lengthy introduction includes a simplified discussion of roentgen-ray physics and the general considerations underlying radiation therapy, and the concluding chapter deals with contraindications.

Most radiologists will find it difficult to accept the author's conviction that any physician can safely undertake the roentgen treatment of infections without special training or experience.

Collected clinical reports from many sources are used to emphasize the value of irradiation, both as a prophylactic and a curative procedure in the treatment of gas gangrene. Unfortunately most of the reports include only a few cases and the group of patients studied personally by the authors seems hardly large enough to justify some of their sweeping statements. They confidently predict that the general adoption of their plan of roentgen therapy given early in the disease will reduce the mortality to 10 per cent and they insist that the wounded men in our armed forces should receive the benefit of their technique. Many of the unfavorable results are attributed to the presence of arteriosclerosis or diabetes and they feel that serum and the sulfonamides have relatively little to offer. Some of their poor results with irradiation are believed to be due to an antagonistic effect of sulfanilamide, and their enthusiasm is in no way dampened by persistently negative results obtained with roentgen treatment of animals infected with proved strains of *Clostridium welchii*.

This book represents a large amount of hard work in a new field and it should stimulate much confirmatory investigation in some of the large research centers.

CHARLES L. MARTIN

PHYSICAL MEDICINE: THE EMPLOYMENT OF PHYSICAL AGENTS FOR DIAGNOSIS AND THERAPY. By Frank H. Krusen, M.D., F.A.C.P., Associate Professor of Physical Medicine, the Mayo Foundation, University of Minnesota; Head of the Section on Physical Therapy, the Mayo Clinic; Member of the Council on Physical Therapy of the American Medical Association, etc. Cloth. Price, $10.00. Pp. 846, with 351 illustrations. Philadelphia: W. B. Saunders Company, 1941.

The author could not have chosen a better title for his book because it indicates definitely that physical therapy is an integral part of Clinical Medicine and also that it includes, as shown in the subtitle, the employment of physical agents for both diagnosis and therapy. To appreciate its scope, its possibilities, one must not only read this book once but study its contents, which is made easy by the logical manner in which the subject matter is presented. As stated in the preface a uniform approach is used under the following headings: Introduction—definition—development—present status; physics; source, device or method of production; physiologic effects; technic of application; indications; contraindications, dangers and limitations; and conclusions. All phases of physical medicine are discussed: history of physical therapy; general application of heat; local application of heat; local and general applications of cold; light therapy; electrotherapy (the constant [galvanic or direct] current; static electricity; the faradic current; the interrupted galvanic and sinusoidal currents; diathermy); hydrotherapy; and mechanotherapy (massage, exercise, rest and relaxation and mechanical devices). There are additional chapters dealing with the clinical aspects of physical medicine, a brief discussion of physical therapy of arthritis, physical therapy in relation to orthopedic surgery, and the important and much debated subject of backache. The teaching of physical medicine to physicians, medical students and technicians is clearly outlined and the author's conclusions should be wholeheartedly endorsed. Problems regarding the hospital department of physical therapy are related in the last chapter and the Section on Physical Therapy at the Mayo Clinic is briefly described. A detailed bibliography accompanies each chapter and the index is excellent.

It is difficult to find any flaws or shortcomings in this book because such a wealth of accurate and valuable information has been assembled between its covers. It is recommended, therefore, not only as a textbook to medical students and practicing physicians but also as a valuable guide for daily reference to those specializing in physical therapy.

ERNST A. POHLE

THE TREATMENT OF BURNS. By Henry N. Harkins, M.S., M.D., Ph.D., F.A.C.S., Associate Surgeon, Henry Ford Hospital, Detroit; Formerly Instructor in Surgery, University of Chicago; John Simon Guggenheim Memorial Fellow in Surgery, 1938–1939. Cloth. Price, $6.50. Pp. 457, with 120 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

It has been widely acknowledged of late years that the treatment of burns is still unsat-

isfactory. Involving as they do problems of local wounds and general physiological abnormalities, they present in a concentrated form nearly all complications known to the surgeon. Clinical and laboratory studies have been carried on at an accelerated pace with the stimulus of the anticipation of mass occurrence of burns due to war action and civilian bombing.

Many controversial points still exist but this is an opportune time for summarizing the subject and making available the very considerable knowledge to most of us who have the time neither to cover the extensive literature nor to evaluate the new developments. The author is exceedingly well qualified to do this as he has made many important experimental studies on the subject, has had a wide clinical experience and an opportunity during his Fellowship to cover exhaustively the wide literature.

The book is presented in four parts, the burn and its effects, treatment, special burns including electrical and radiation burns, chemical burns and freezing and in Part IV a practical outline of burn treatment from which controversial points are omitted and definitive instructions are given for treatment of the burned patient in the home, by physicians and in the hospital. All phases of this injury including pathology, chemical changes, shock, fluid loss, infection, all recognized methods of treatment of all stages including plastic correction of scar are well and impartially presented. The illustrations are happily chosen, being informative and practical. Full page pictures with biographies of Dupuytren, Curling, Underhill and Davidson add historical atmosphere and interest. The book is perfectly documented with a bibliography of over thirteen hundred references. These include all papers on the subject up to the minute of publication. To make the bibliography accessible, there is appended to it a guide that directs reading by chapter, author and subject.

This is a most complete authoritative and up-to-date presentation of this important subject. Aside from the material on burns there is description of research that is important in other surgical problems, and discussions of surgical philosophy that will be valuable to all surgeons. The work is important from a historical standpoint as it presents a complete summary of the literature on the subject. To anyone interested in burns, in shock, in wound healing (all fundamentals of surgery) the book will be important. It is the only source for a complete bibliography, with a compilation and an impartial presentation of the controversial aspects concerning treatment now available. The practical and dogmatic advice concerning treatment makes its reading nearly obligatory to the family physician, the intern and resident, and its scholarly development of the entire theme will make it of interest to the most seasoned of surgeons. It is, in short, a finished picture of the subject, its history, literature, and unanswered problems, together with practical, usable advice about treatment of this dreadful form of trauma. The author and publisher are to be heartily commended for giving us this volume.

FREDERICK A. COLLER

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

HARE, H. F.: Roentgen changes in the cranial vault accompanying diseases resulting from metabolic disturbances 269
NEWELL, R. R., and BORLEY, W. E.: Roentgen measurement of visual acuity in cataractous eyes 269
WILLIAMS, E. R.: On the radiological aspects of an investigation into the relationship of chronic irido-cyclitis, uveo-parotitis and tuberculosis 270

Neck and Chest

JESSEL, G.: The rôle of mass radiography in tuberculosis 270
PAUL, L. W., and POHLE, E. A.: Mediastinal and pulmonary changes in erythema nodosum 271
NESSA, C. B., and RIGLER, L. G.: The roentgenological manifestations of pulmonary edema 271
BERG, G., and ZACHRISSON, C. G.: Cystic-lungs of rare origin—tuberous sclerosis 271
WESTERMARK, N.: Roentgenological investigation into traumatic lung changes arisen through blunt violence to the thorax 271
BALL, R. P., and CRUMP, A. C.: Mega-esophagus (cardiospasm) 272
CHRISTIANSEN, H.: Brachyesophagus with dystopic cardia 272
GRISHMAN, A., STEINBERG, M. F., and SUSSMAN, M. L.: Tetralogy of Fallot: contrast visualization of heart and great vessels .. 273
BECK, C. S.: Compression of the heart 273
VIETA, J. O., and CRAVER, L. F.: Intrathoracic manifestations of the lymphomatoid diseases 273
GOSSE, A. H.: A right-sided aorta 274
EDLING, N. P. G.: Aneurysm of an intercostal artery with simultaneous, sarcomatous destruction of an adjacent, dorsal vertebra 274
RIGOS, F. J.: Roentgenographic study of pleural effusion 274

Abdomen

FELDMAN, M.: New roentgen sign of pyloric obstruction 275
CRAIG, W. J.: Primary carcinoma of the jejunum 275
MCMULLEN, J. W.: Roentgenographic study of relative incidence of gastric and duodenal ulcer 275
REES-JONES, G. F.: Diaphragmatic movement after lower abdominal operations 275
BEILIN, D. S.: Diaphragmatic hernia of the stomach 276
POPPEL, M. H., and LEVY, A. H.: Pancreatic lithiasis 276
BROWN, S., MCCARTHY, J. E., and FINE, A.: Pancreatic tumors 276
LEVITIN, J.: Intraperitoneal localized abscess 276
HOLMGREN, B. S.: Two interesting cases of volvulus of the sigmoid 277
LEWIS, R. I.: A case of lympho-granuloma inguinale producing rectal stricture 277
RENANDER, A.: Roentgenologic features of tuberculosis of the rectum 277

Genitourinary System

RIDLON, G. R.: Atypical pyelograms in cystic disease of the kidney 278
WILLIAMS, E. R.: Pyelo-renal backflow 278
NOWELL, S.: Increasing density of the renal shadow during excretion urography 278
WYATT, G. M.: Excretory urography for children 279
BOWEN, J. A., and SHIFLETT, E. L.: Intravenous urography in the upright position 279
THOMAS, G. J., STEBBINS, T. L., and SANDELL, S. T.: Roentgenology of renal tuberculosis 279
RENANDER, A.: Another case of spontaneous rupture of the renal pelvis 280
WILLIAMS, E. R.: Subcapsular rupture of the kidney 280
ROBERTSON, T. D., and HAND, J. R.: Primary intrarenal lipoma of surgical significance 280
BUGBEE, H. G.: Exploration of certain renal tumors 281
BUGBEE, H. G.: Tuberculoma of the kidney .. 281
FOWLER, H. A.: Bilateral renal ectopia 281
HYAMS, J. A., and KENYON, H. R.: Localized obliterating pyelonephritis 282
PATERSON, R.: Cancer of the bladder 282
GREENFIELD, H.: Distant metastases from carcinoma of the urinary bladder 282
CLANCY, F. J.: Neoplasm complicating diverticulum of the bladder 283
COLLINGS, C. W., and WELEBIR, F.: Osteoma of the bladder 283
STRAUSS, B.: The roentgen demonstration of the prevesical spaces 283
KATZEN, P.: Metastatic carcinoma of the epididymis 283
HERGER, C. C., and SAUER, H. R.: Relationship of serum acid phosphatase determina-

tion to presence of bone metastases from carcinoma of prostate..... 284
Seaman, J. A., and Binnig, C.: Urological complications of cancer of the rectum..... 284

Skeletal System

Howes, W. E., and Schenck, S. G.: Roentgenologic considerations in diagnosis and treatment of primary malignant bone tumors..... 285
Campbell, W. C., and Hamilton, J. F.: Gradation of Ewing's tumor (endothelial myeloma)..... 285
Aitken, A. P.: Roentgenographic recognition of synovioma..... 286
Kibby, S. V.: Melorheostosis..... 286
Camp, J. D., and McCullough, J. A. L.: Pseudofractures in diseases affecting the skeletal system..... 287
Hart, V. L.: Two unusual injuries of the wrist 287
Carter, R. M.: Carpal boss..... 287
Cave, E. F.: Retrolunar dislocation of the capitate with fracture or subluxation of the navicular bone..... 288
Soto-Hall, R., and Haldeman, K. O.: The conservative and operative treatment of fractures of the carpal scaphoid (navicular)..... 288
Sachs, M. D., Hill, H. A., and Chuinard, E. L.: Further studies of the shoulder joint with special reference to the bicipital groove..... 288

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Hare, Hugh F. Roentgen changes in the cranial vault accompanying diseases resulting from metabolic disturbances. *Radiology*, June, 1941, *36*, 706–711.

The author calls attention to the fact that many diseases in which there are metabolic disturbances bring about changes in the bones which can be demonstrated by roentgen examination. Among such diseases are hyperparathyroidism, hyperthyroidism, non-tropical sprue, hypogonadism, menopausal osteoporosis, Cushing's syndrome, calcinosis universalis, osteomalacia, multiple myeloma, osteitis deformans, and metastatic malignancy. In all of these diseases there is osteoporosis and in some of them cystic changes in the bones, particularly of the vault of the skull. While the changes are not specific and a definite diagnosis of the disease cannot be made from the roentgenogram alone the roentgenologist may be able to suggest to the physician certain lines of clinical and laboratory investigation that will help to clear up the diagnosis. The study of calcium balance is particularly important. Roentgenograms are shown from cases of hyperparathyroidism, non-tropical sprue and hypogonadism.—*Audrey G. Morgan.*

Newell, R. R., and Borley, W. E. Roentgen measurement of visual acuity in cataractous eyes. *Radiology*, July, 1941, *37*, 54–61.

The authors discuss the physiology of roentgen-ray vision and describe their method of testing retinal function by means of roentgen rays. Eyes with different degrees of defective vision resulting from opacities of the media can be tested, regardless of the type or density of the opacity. Their experience in testing the eyes by this method in 61 cases before cataract operation is described. The results were such that they believe it will be possible to avoid most cases of poor vision after cataract operation by the use of this method and attention to vitamin A nutrition.

In the discussion Dr. Bruner said that he thought there were a good many practical clinical objections to this method. The time required for carrying it out seems to be out of proportion to the results obtained. The authors seem to have failed to take into account the fact that many patients with cataract have poor fixation. The test gives considerable information in regard to peripheral function but it is questionable whether it gives much in regard to macular function. The presence of central scotoma and retinal detachment can be determined just as easily by clinical methods. Central scotoma may be overlooked by any known method

and no matter how good the diagnosis many things can happen after the diagnosis is made, so that the skill of the surgeon and the cooperation of the patient are still the most important factors in giving good results.

In closing Dr. Newell said that the problem of fixation had not yet been settled. Roentgen-ray measurement of visual acuity is time consuming but that does not matter if it gives the patient something he cannot get in any other way. He believes Dr. Bruner misunderstood the purpose of the method which is to discover a scotoma or retinal detachment when opaque media make its discovery by clinical means impossible. If more can be discovered about the function of the retina before a cataract is removed it will be a great help to the patient. Even if it is impossible to guarantee reading vision after removal of a cataract it may be possible in some cases to tell the patient that it is impossible to restore reading vision by operation and give him the choice as to whether he wants operation under those circumstances.—*Audrey G. Morgan.*

WILLIAMS, E. ROHAN. On the radiological aspects of an investigation into the relationship of chronic irido-cyclitis, uveo-parotitis and tuberculosis. *Brit. J. Radiol.*, April, 1941, *14*, 116–127.

That certain chronic diseases of the eye are caused by tuberculosis has been proved by histological evidence. There is still considerable controversy as to the cause of others, including chronic irido-cyclitis and uveitis associated with parotitis. Tuberculous infection has been suspected to be the cause of these diseases also but many ophthalmologists have not been convinced of this.

As improvement in roentgen technique has made earlier and more accurate diagnosis of pulmonary tuberculosis possible, the author decided to make an investigation of this question. Roentgen examinations of the lungs were made in 40 cases of chronic irido-cyclitis from ophthalmological hospitals in London. There were positive findings in the lungs in 24 of these cases; there were old healed fibrotic or calcified pulmonary foci in 4 cases, active chronic pulmonary tuberculosis in 6, massive mediastinal and hilar lymph node enlargement in 2 and diffuse miliary and reticular pulmonary changes in 12. Among these 12 cases in which the roentgen findings suggested chronic miliary tuberculosis, tubercle bacilli or indisputable histological evidence of tuberculosis were found in 4. The parotitis and irido-cyclitis were only local manifestations of a generalized disease. The only other conditions with which the pictures could be confused were Schurmann's lymphangitis reticularis chronica and sarcoidosis and both of these are believed to be tuberculous in nature.

Six of the cases are described in detail and illustrated with roentgenograms.—*Audrey G. Morgan.*

NECK AND CHEST

JESSEL, G. The rôle of mass radiography in tuberculosis. *Brit. J. Radiol.*, June, 1941, *14*, 206–209.

Even with improved methods of roentgen examination the diagnosis of early tuberculosis is difficult because the amount of roentgen involvement does not run at all parallel with the severity or activity of the disease. The clinical facts must also be taken into consideration in judging of the activity of any given case.

Nevertheless mass roentgenography in the form of making photographs of the screen picture on miniature film and enlarging it has proved valuable both in industry and the army, chiefly in weeding out cases that require further roentgen and clinical examination. The fitness of a person for service should never be decided on the basis of the miniature film alone but should only mean that the man is to be sent for more complete examination and full-size roentgenograms made. This further examination and interpretation should be made by a team of radiologists and clinicians with experience in the diagnosis of tuberculosis.

Roentgenography in the diagnosis of tuberculosis has certain very definite limitations. A roentgenogram only shows the conditions present at the time of the examination. A negative finding does not guarantee that tuberculosis will not develop later. Therefore mass examinations must be repeated at intervals. Even if the findings indicate tuberculosis it does not necessarily mean that the disease is active. The roentgen findings may be consistent with other diseases as well as tuberculosis.

Mass examinations should not be associated in the public mind with tuberculosis because of the psychological effect. They should be considered a part of a general health survey and should not be made at a tuberculosis dispensary. Definite standards of technique and interpretation must be adopted if comparable results are to be attained.—*Audrey G. Morgan.*

PAUL, L. W., and POHLE, E. A. Mediastinal and pulmonary changes in erythema nodosum. *Radiology*, Aug., 1941, *37*, 131–137.

Little attention seems to have been paid to roentgen examination of the lungs in erythema nodosum. It has been quite generally assumed that this disease is a specific infection of unknown origin or is due to rheumatic fever or streptococcus infection.

The authors have made roentgen examinations of the chest in 20 cases of erythema nodosum. Histories and roentgenograms of a number of the cases are given. All but one of the patients were adults. In 8 cases there were no roentgen signs of previous or present disease of the chest. In 3 there were slight signs probably not related to the erythema nodosum. In 3 there were slight but definite signs of disease of the lymph glands at the hilum and in 6 very marked enlargement of these glands. In 2 of the cases it was definitely proved that the enlargement of the glands was caused by tuberculosis and in 4 others tuberculosis was believed to be the cause of the gland disease and the erythema nodosum.

The authors believe that in all cases of erythema nodosum roentgen examination of the chest should be made as in enlarged hilum glands both the gland enlargement and the erythema nodosum are apt to be caused by tuberculosis. Even if the first examination is negative follow-up examinations should be made before the patient is discharged as free of tuberculosis. They do not claim that all cases of erythema nodosum in adults are caused by tuberculosis but they want to emphasize the fact that not all of them are caused by rheumatic fever or streptococcus infection and to stress the importance of roentgen examination of the chest.—*Audrey G. Morgan.*

NESSA, CURTIS B., and RIGLER, LEO G. The roentgenological manifestations of pulmonary edema. *Radiology*, July, 1941, *37*, 35–46.

Little has been written about the roentgen findings in pulmonary edema. As the condition is acute it is often not thought advisable to take the seriously ill patient to the roentgen room.

The authors discuss 110 cases of pulmonary edema that came to necropsy. In 18 of these roentgen examinations had been made before death. Seven of the cases are described in detail and illustrated with roentgenograms in order to show the different pictures presented. The classical type with bilateral, symmetrical, homogeneous widespread density does not occur in the majority of cases. The fluid tends to collect in the center of the lungs, leaving the periphery clear. This results in a butterfly-shaped density. In 1 of the cases described the fluid collected first in groups of alveoli which later became confluent, giving stippled, irregular but widespread densities. Pulmonary edema may be localized to one lobe or one lung and so simulate pulmonary edema or infarct. No satisfactory explanation can be given for this localization. It cannot always be diagnosed when the picture is atypical but it should be considered in cases of heart failure, kidney disease, liver disease, after operations and following transfusion reactions. One notable cause of pulmonary edema is the administration of excessive amounts of fluid after operation. Though the author chose cases which came to autopsy for the purposes of his paper many patients recover from pulmonary edema following operation.—*Audrey G. Morgan.*

BERG, GUNNAR, and ZACHRISSON, C. G. Cystic-lungs of rare origin—tuberous sclerosis. *Acta radiol.*, 1941, *22*, 425–436.

Three cases of cystic lungs from tuberous sclerosis are described. Two of the patients were sisters and in the elder the disease proved fatal. The disease is known to be familial. The roentgenogram shows a honeycomb-like appearance of the lungs due to the presence of many cysts with septa of varying thickness between them. In the case which was autopsied there were tumors in the brain and kidneys of the same nature as those that have been described previously in tuberous sclerosis.

The differential diagnosis of this condition is discussed and roentgenograms given showing the appearance in this form of cystic lung, cystic lung in diabetes insipidus, acute and chronic miliary tuberculosis, benign lymphogranuloma, silicosis and lymphangitis carcinomatosa reticularis.—*Audrey G. Morgan.*

WESTERMARK, NILS. A roentgenological investigation into traumatic lung changes arisen through blunt violence to the thorax. *Acta radiol.*, 1941, *22*, 331–346.

Traumatic lesions of the lungs from blunt violence to the thorax may be brought about by laceration of the tissues by fragments of fractured bones. But they may also occur when

there has been no fracture. Sudden compression of the lung may cause rupture of the bronchi and vessels followed by the secondary appearance of interstitial emphysema and hemorrhage. If infection of hemorrhagic infiltrations occurs it may cause severe disease, such as acute or chronic bronchitis, bronchiectasis, pneumonia, gangrene of the lung, pleurisy or empyema.

The author reports 124 cases of blunt injury of the thorax in which roentgen examination was made immediately after the accident. There were changes in the lungs in 94 of these, or 75.8 per cent. Among the cases in which there was fracture there were changes in the lungs in 86.7 per cent (52 out of 60 cases) and among those in which there was no fracture there were lung changes in 65.6 per cent (42 out of 64). As the violence was doubtless greater in the fracture cases it would seem that roentgenographic lung changes increase with increased degrees of violence.

The lung changes cleared up after two to three weeks in 53.2 per cent of the cases. In these cases they were slight and caused no symptoms. In 46.8 per cent (44 out of 94) there were more or less severe complications, such as empyema, pneumonia and bronchitis. These generally came on four to fourteen days after the accident.

As there are usually no symptoms in these cases unless complications develop, it is well to have a roentgenogram made early. From the medicolegal point of view lung diseases are not acknowledged to be of traumatic origin unless symptoms appear within three to four days after the accident. Judging from the author's material post-traumatic pneumonia may occur later than this. Early roentgenograms may be of value in proving the traumatic origin of the disease in such cases.—*Audrey G. Morgan.*

BALL, ROBERT P., and CRUMP, ARMISTEAD C. Mega-esophagus (cardiospasm); report of a case with subdiaphragmatic herniation of the esophagus. *Radiology*, May, 1941, *36*, 575–582.

A case is reported in a student nineteen years of age who had just graduated from high school and had suffered emotional shock in the death of a grandmother of whom he was very fond. He began to have difficulty in swallowing and a feeling of pressure beneath the sternum which grew steadily worse. Finally he was obliged to empty the esophagus before going to bed by lowering his head and spasmodically contracting the abdominal muscles. It was over a year before he consulted a physician.

Roentgen examination showed the esophagus dilated with a considerable amount of food residue. The dilated part of the esophagus passed through the hiatus in the diaphragm and reached to about 12 cm. below it, ending in a dilated pouch. At intervals deep contractions occurred, sometimes several at a time, giving the esophagus a writhing, twisting movement. No barium passed out of the distal end until the patient forced it out.

Treatment by lavage was unsuccessful and the dependent part of the esophagus was anastomosed with the pars media of the stomach near the lesser curvature. Re-examination some six months later showed the esophagus smaller, its length had decreased and the stoma was near the level of the hiatus. The patient could eat anything he wished without difficulty.—*Audrey G. Morgan.*

CHRISTIANSEN, HARALD. Brachyesophagus with dystopic cardia. *Acta radiol.*, 1941, *22*, 360–366.

There are cases in which the esophagus is congenitally short and the cardia displaced upward into the thorax. Up to 1931 very few cases had been reported but in that year Findlay and Kelly published a case of stricture of the esophagus in the thorax with gastric mucosa immediately below it continuing down into the stomach. These cases are apt to be confused with ones of diaphragmatic hernia and roentgen examination is important in the differentiation.

The author describes 4 cases, 2 in infants and the other 2 in elderly adults. The 2 latter patients died and autopsy confirmed the roentgen diagnosis. Roentgen examination showed a constriction of the esophagus at the 6th to 8th vertebra with gastric mucosa passing down from it.

The abnormality does not necessarily cause symptoms but constriction of the cardia may cause spasm and vomiting as in the author's first case, or it may cause hematemesis as in the second case in which the stomach was incarcerated in the muscular part of the diaphragm. In the third case, in a woman of fifty-three, there was a carcinoma of the cardia but it is not known whether there was any connection between it and the malformation. In the fourth case there was inflammation of the cardia which finally led to complete stenosis.

The treatment is symptomatic, particularly dilatation of the stenosis.—*Audrey G. Morgan.*

Grishman, A., Steinberg, M. F., and Sussman, M. L. Tetralogy of Fallot: contrast visualization of heart and great vessels. *Radiology*, Aug., 1941, *37*, 178–180.

Since Robb and Steinberg first published their work on contrast visualization of the heart chambers in 1938 it has been found useful in the study of congenital heart disease. The authors report a case in which the pathological physiology of tetralogy of Fallot was established by this method. They have not found any similar report in the American literature. Roentgenograms and drawings made in the left anterior oblique position are given.

The patient was an Italian man of twenty-six who has had cyanosis and clubbed fingers since birth. He was fairly active until March, 1938, when he was admitted to the hospital complaining of pain in the right lower chest and dyspnea. A contrast visualization by the original method of Robb and Steinberg was not conclusive. In May, 1940, the examination was repeated using both the moving picture and the multiple exposure techniques with diodrast. These showed hypertrophy and dilatation of the right ventricle, stenosis of the pulmonary artery above the conus, a defect in the intraventricular septum with right to left shunt and dextroposition of the aorta. The left ventricle was very small and remained visible long after the other parts of the heart and great vessels. Evidently there was no outlet from the left ventricle except through the defect in the septum.

The fluorographic multiple exposure technique or the cineroentgenographic method is necessary in such cases as that is the only way in which a sufficient number of exposures can be made in a short time.—*Audrey G. Morgan.*

Beck, Claude S. Compression of the heart. *Radiology*, July, 1941, *37*, 47–53.

Chronic compression of the heart, which is the condition considered in this article, is generally caused by pericardial scars, though it may be caused by blood, pus, transudate or exudate in the pericardial cavity or mediastinum, tumors of the heart or pericardium or strangulation of the heart through a rent in the pericardium. It differs from acute compression in the fact that venous pressure can rise much higher. The unmistakable symptoms are ascites, high venous pressure, quiet, small heart, and enlargement of the liver. In many cases there are calcifications in the pericardium. Contrary to quite generally accepted opinion adhesions with traction in the long axis of the heart do not cause extrinsic heart disease.

No medical treatment is of any avail in chronic compression of the heart but the condition can be relieved almost as if by magic by surgical operation on the scars that cause it. The ascites disappears, circulation becomes normal and the subject is changed from a chronic heart patient to a normal, healthy person. The cure is permanent and there is little risk in the operation if it is performed with due surgical skill.

Photographs are given of patients before and after operation.—*Audrey G. Morgan.*

Vieta, John O., and Craver, Lloyd F. Intrathoracic manifestations of the lymphomatoid diseases. *Radiology*, Aug., 1941, *37*, 138–159.

The authors report the roentgen examination of 794 cases of lymphomatoid disease with postmortem examination in 160 cases. These showed a high percentage of lesions in the chest and they believe that if more frequent roentgen examinations of the chest were made the percentage would be even higher than in this series. Often these intrathoracic lesions are silent clinically and roentgen examination furnishes the only means of arriving at knowledge that will make it possible to treat the deep-seated lesions of these diseases.

In the roentgen examination of 335 cases of Hodgkin's disease there were intrathoracic lesions in 74 per cent, and postmortem examination showed lesions in 88 per cent. Among 239 cases of lymphosarcoma roentgen examination showed intrathoracic involvement in 54 per cent and autopsy in 73 per cent, less than in Hodgkin's disease. In 158 cases of lymphatic leukemia the chest was found involved in 72 per cent on roentgen examination and the mediastinal or hilar nodes were involved in 83 per cent of the 31 cases examined postmortem. In 52 cases of myelogenous leukemia 82 per cent showed no intrathoracic lesions on roentgen examination and among the 23 cases autopsied 52 per cent were free of chest lesions. There was myeloidization of enlarged mediastinal or hilar nodes in 47 per cent. In 10 cases of mycosis fungoides mediastinal or hilar nodes were found in 10 per cent and parenchymal infiltration in 30 per cent. No autopsy material was available

in this disease. Tables are given showing details in regard to the nature and distribution of the lesions in the various diseases.

Attention is called to the fact that patients with lymphomatoid disease may also have other types of tumor. Among the authors' 160 autopsied cases there were 4 with malignant tumors of the gastrointestinal tract.—*Audrey G. Morgan.*

GOSSE, A. HOPE. A right-sided aorta. *Brit. J. Radiol.*, June, 1941, *14*, 215–216.

Aorta on the right side is extremely rare. A case in a man of fifty-six is described which is particularly interesting from the fact that it had never caused any disturbance of any kind. The patient was sent to the author with a diagnosis of malignant mediastinal tumor based on a homogeneous shadow to the right of the sternum in the upper mediastinum. The author's examination showed that the symptoms were caused by a resolving dry pleurisy. He had taken a roentgenogram of the patient in 1936 and comparison showed that the shadow on the right side had not changed in four years, showing that it could not be due to malignant glands in the mediastinum. He believed it was due to a right-sided aorta and this diagnosis was confirmed by a specialist. Two roentgenograms of the case are given and an electrocardiogram made in 1936 which showed only the preponderance of the left ventricle so common in middle life and later, and no abnormalities.—*Audrey G. Morgan.*

EDLING, NILS P. G. Aneurysm of an intercostal artery with simultaneous, sarcomatous destruction of an adjacent, dorsal vertebra. *Acta radiol.*, 1941, *22*, 411–421.

A case is described in a man of forty-six who had been well until about a year before admission to the hospital when he began to suffer from digestive disturbance and dull abdominal pain under the right costal arch radiating to the back and up under the right shoulder. Roentgen examination showed a round dense area the size of an infant's head in the lower part of the right lung field, adjoining the heart shadow. It could not be projected free from the spinal column but was separated from the diaphragm, the mobility of which was normal. No details could be seen in the opaque area. Its center was on a level with the 9th dorsal vertebra which showed a rarefaction the size of a hazelnut on the right side. From the roentgenograms a diagnosis was made of primary tumor in the right lung with metastasis in the 9th dorsal vertebra, or of a neurinoma growing from the spinal canal. The latter diagnosis was considered rather the more probable.

The patient's condition grew rapidly worse and it was impossible to make further roentgen examination. He died eight weeks after admission.

Autopsy showed an osteolytic sarcoma which was apparently primary in the 9th thoracic vertebra. It also showed an aneurysm of an intercostal artery filled with thrombotic masses. The aneurysm was apparently much older than the sarcoma which had evidently had a very rapid destructive action and yet had not spread beyond the one vertebra. There was no evidence of an etiological relationship between the two processes and the only theory that would satistorily account for both of them would be that of trauma. There was no history of either trauma or previous disease but as the patient was a lumberman he may conceivably have suffered some injury which damaged the intercostal artery and caused the aneurysm and, after a latent period, the osteogenic sarcoma.

The case shows the difficulty of interpreting rounded shadows in the thorax.—*Audrey G. Morgan.*

RIGOS, FRANK J. A roentgenographic study of pleural effusion. *Radiology*, May, 1941, *36*, 568–574.

Between 1919 and 1938, 5,731 patients were admitted to the Glen Lake Sanatorium; of these 233 had pleural effusions. The age and sex distribution of the effusion cases was practically the same as that of the general admissions for tuberculosis. The figures for effusion as compared with those for tuberculosis by stages show that pleural effusions form more frequently cases of minimal and moderately advanced tuberculosis than in far advanced cass. Roentgenograms showed that 172 of the patients had typical effusion and 41 massive effusion. These two groups constituted 97 per cent of the whole number of cases. The other 3 per cent were atypical. In the upright roentgenogram effusions of less than 400 cc. cannot be detected. In about 75 per cent of the cases the associated tuberculosis was of the nodular or fibrotic type. The type of tuberculosis could be diagnosed from the roentgenogram in 197 of the cases. In the remaining 36 the pulmonary lesion was hidden by the effusion. There were cavities on

the same side as the effusion in 34 cases, on both sides in 20 and on the opposite side in 12 cases.

Later studies were made on 190 cases. It was found that prognosis was somewhat better in cases that had a small amount of effusion. The resolution of the effusion was not dependent on cure of the associated tuberculosis. Among the 72 cases in which roentgenograms were available 31 showed complete resolution and 41 incomplete. The complete resolution had occurred in 19 of the cases (60 per cent) within two years. The most frequent finding in the cases with incomplete resolution was obliteration of the costophrenic angle by adhesions. Cases in which there was a large amount of fluid and in which aspiration was performed did not show as complete resolution as those in which there was less fluid and aspiration was not done. The commonest and most persistent roentgen finding was obliteration of the costophrenic angle.—*Audrey G. Morgan.*

ABDOMEN

FELDMAN, MAURICE. A new roentgen sign of pyloric obstruction: the roentgen visualization of the stomach without the use of contrast media. *Radiology*, June, 1941, *36*, 736–738.

If a homogeneous image of the whole stomach can be seen without contrast medium in a fasting patient it indicates gastric retention caused by obstruction of the pylorus. This is a new roentgen sign of pyloric obstruction and is caused by the excessive amount of fluid retained in the stomach. This shadow may resemble that of a tumor of the stomach, an aortic aneurysm, a tumor or cyst of the kidney, a subdiaphragmatic abscess or a diaphragmatic tumor, an enlarged spleen, an adrenal tumor, a cyst of the pancreas, or an enlargement of the left lobe of the liver.—*Audrey G. Morgan.*

CRAIG, W. JOHNSTON. Primary carcinoma of the jejunum: a case report. *Brit. J. Radiol.*, June, 1941, *14*, 210–212.

A case is described in a woman of forty-eight, who for some months had complained of pain which had lately become colicky in type. She had vomited occasionally and had lost some weight. Roentgen examination showed nothing abnormal in the stomach or jejunum. Therefore a careful examination was made of the jejunum which showed a stricture at 3 to 4 inches beyond the duodenojejunal junction with dilatation above it. A diagnosis of malignant lesion of the jejunum was made and operation performed a week later. During this interval the vomiting had become more frequent. A tumor was found at the site indicated in the roentgenogram and histological examination showed it to be a papillary alveolar and tubular columnar cell carcinoma of the jejunum. Two roentgenograms and a photograph of the specimen are given. The patient made an uneventful recovery. The prognosis is bad in these cases. Rankin of the Mayo Clinic says that the average duration of life after operation is one year.

The importance of making a careful examination of the small intestine and not being content with normal findings in stomach and duodenum is emphasized.—*Audrey G. Morgan.*

MCMULLEN, J. W. A roentgenographic study of the relative incidence of gastric and duodenal ulcer. *Radiology*, Aug., 1941, *37*, 194–196.

It was formerly thought that gastric ulcer is more common than duodenal ulcer but recent statistics have tended to reverse this proportion. The author made a study based on 4,400 consecutive gastrointestinal examinations from 1926 to 1939 at the Colorado General Hospital. A total of 883 gastric and duodenal ulcers was seen—that is, an incidence of slightly more than 20 per cent of the whole number of cases examined. Of these 689, or 78 per cent, were duodenal, and 194, or 22 per cent, were gastric. The figures in the literature show a wide variation from these percentages.

A curve is given showing the incidence of gastric and duodenal ulcer in men and women for the different decades of life based on these cases. The relative incidence of duodenal and gastric ulcers is 3:1 for women and 4:1 for men. The peaks of incidence of gastric and duodenal ulcer in women were found in the fifth and fourth decades respectively while in men they were in the sixth and fifth decades respectively.—*Audrey G. Morgan.*

REES-JONES, G. F. Diaphragmatic movement after lower abdominal operations. *Brit. J. Radiol.*, July, 1941, *14*, 247.

A table is given showing the results of screen examination to determine the excursion of the diaphragm after herniotomy and appendectomy. Screen examinations were made six, twenty-four, forty-eight and seventy-two hours

after operation. It was found that on quiet respiration there was very little movement of the diaphragm for twenty-four hours after operation. The diaphragm was more fixed and remained fixed longer on the side of the operation than on the opposite side. It was more fixed after fascial repair for inguinal hernia than after appendectomy. The diaphragmatic movements frequently returned to normal after forty-eight hours and almost always after seventy-two hours. The examinations show that a fixed diaphragm on the side of the operation for forty-eight to seventy-two hours has no pathological significance. Complications developed in only 1 of the 30 cases examined here. This was an atelectasis of the left lower lobe and examination before operation had shown a fixed diaphragm on the opposite side.—*Audrey G. Morgan.*

BEILIN, D. S. Diaphragmatic hernia of the stomach. *Radiology*, July, 1941, *37*, 68–74.

The author discusses the anatomy and embryology of diaphragmatic hernia and reviews 26 cases of his own. Among these patients 1 also had carcinoma of the stomach, 3 had duodenal ulcer, 1 diverticulitis of the esophagus, 1 diverticulum of the cardiac portion of the stomach and 1 gallbladder disease with gallstones.

The symptoms of diaphragmatic hernia of the stomach may be respiratory or gastrointestinal or a combination of the two. In many cases they are so varied and uncharacteristic that they have little value. The chief means of diagnosis is by roentgen examination.

If the symptoms are mild medical treatment may be sufficient. Patients often go through life without any very great disturbance from such a hernia. But if the symptoms are severe enough to warrant it operation should be performed, the herniated viscera replaced in the abdomen and the abnormal opening in the diaphragm repaired.

Among the author's cases 8 were operated on and 18 treated symptomatically. Of the 8 patients operated on 7 recovered uneventfully and 1 died. One had a moderate recurrence of the hernia six months later. In the 1 case that was autopsied the whole stomach and left splenic flexure were in the left half of the chest. The tendinous part of the left diaphragm was defective with a rent 10 cm. long. The patient died from shock.

Spot roentgenograms should be taken of all diaphragmatic hernias that are of clinical significance.—*Audrey G. Morgan.*

POPPEL, M. H., and LEVY, A. H. Pancreatic lithiasis. *Radiology*, Aug., 1941, *37*, 174–177.

Three cases of lithiasis of the pancreas are described and illustrated with roentgenograms. Roentgen examination is the only certain method of diagnosing this condition which was only rarely diagnosed during life before the introduction of roentgenography.

These calculi are generally composed of calcium carbonate and phosphate. They result from pancreatitis and alcoholism is a prominent factor in their production. Pain resembling that of gallbladder colic is a frequent symptom. Roentgen examination generally shows multiple dense calculi along the course of Wirsung's duct.—*Audrey G. Morgan.*

BROWN, SAMUEL, MCCARTHY, J. E., and FINE, ARCHIE. Pancreatic tumors; a roentgenologic study. *Radiology*, May, 1941, *36*, 596–603.

Roentgen diagnosis of tumor of the pancreas is difficult because the shadows of several organs are superimposed in this region. It can be made indirectly, however, from a study of changes in the position and outline of the stomach and duodenum caused by pressure from the tumor. Twelve cases of tumors of the pancreas and other organs in the region, particularly the common duct, are described and illustrated by roentgenograms, attention being called to the differential signs between tumors of the pancreas and other tumors. Needless to say a thorough knowledge of the normal anatomical relations is a necessity in this diagnosis.

In the discussion the value of the lateral view in this diagnosis was brought out. With this view it is possible to differentiate between lesions of the pancreas posteriorly and lesions of the liver anteriorly. In early enlargements of the head of the pancreas there is an inverted-three filling defect on the medial side of the descending portion of the duodenum. In the prone lateral view a tumor of the pancreas may project forward into the gas-filled stomach and be clearly visible. The stomach is often displaced upward in the recumbent position, especially in obese patients. In such cases the patient should be examined standing also.—*Audrey G. Morgan.*

LEVITIN, JOSEPH. Intraperitoneal localized abscess: roentgenologic aid in diagnosis. *Radiology*, Aug., 1941, *37*, 205–207.

It is sometimes hard to diagnose a localized intraperitoneal abscess, especially after surgical

operation when there are several possibilities. The author discusses two roentgen findings which are of value in such a diagnosis. The first is an ileus, which is not a true paralytic ileus but an inhibition of the action of the bowel due to over-stimulation of the sympathetic by the inflammation. The other is the absence of the normal properitoneal fat line, or the dark stripe caused by the properitoneal fat, which is seen on ordinary roentgenograms. Four illustrative cases are described.

These signs may occasionally be absent, as in a case of ruptured appendix recently seen with quite a severe localized abscess. The mass was buried in the false pelvis beneath the omentum and the area was covered by a dense congenital band which was adherent to the brim of the pelvis and extended over the bladder. The abscess was so isolated from the peritoneum that there was no stimulation of the peritoneum sufficient to cause an ileus. The position of the abscess was such as to prevent infiltration of the properitoneal fat by fluid and therefore the properitoneal fat line was present. But ordinarily these two symptoms furnish a means of diagnosis.—*Audrey G. Morgan.*

HOLMGREN, BENGT S. Zwei interessante Fälle Sigmoideumvolvulus. (Two interesting cases of volvulus of the sigmoid.) *Acta radiol.*, 1941, *22*, 404–410.

The surest way of diagnosing a volvulus of the sigmoid is by roentgen examination. Two cases are described. The first was in a man of eighty who for nine months had had stubborn constipation. After some days of constipation the abdomen distended but collapsed after a stool or enema. The last time he had not been able to relieve the constipation by enema and came to the hospital after five days of absolute constipation.

Roentgen examination showed torsion of at least 360° in a loop of sigmoid. The picture differed from the usual one of volvulus of the sigmoid in the fact that both the ascending and descending colon showed fluid levels and that the cecum and a part of the ascending colon were larger than the twisted sigmoid loop. The picture suggested a deep stenosis of the colon due to cancer rather than volvulus of the sigmoid. The abdomen was opened and a tube passed through the rectum and guided by the hand into the volvulus. Large amounts of gas and fluid were passed and the torsion reduced. The patient was in very bad general condition, however, and died after twelve hours without having regained consciousness.

Another case is described in which the volvulus was reduced without operation by introducing a stomach tube into the rectum and passing it, under screen observation into the volvulus, on which gas and diarrheal intestinal contents was passed and the volvulus was reduced spontaneously. The torsion in this case was loose, while in the previous case it had persisted for five days and was very tightly twisted.—*Audrey G. Morgan.*

LEWIS, R. I. A case of lympho-granuloma inguinale producing rectal stricture. *Brit. J. Radiol.*, Sept., 1941, *14*, 298–299.

Lymphogranuloma inguinale is very rare in England. A case is described in a woman of forty-four who complained of colicky abdominal pain, flatulence, constipation and vomiting and recently a feeling of incomplete evacuation of the rectum. She had lived in Malta and South Africa up to the age of twelve. Her husband had never been abroad. There was a discharging sinus near the anus and the skin around the anus was suppurated. The inguinal glands were enlarged. Barium enema examination showed a marked stricture of the rectum which was so long that it argued against a diagnosis of carcinoma of the rectum. An excised piece of tissue showed chronic inflammation. A Frei test was made and proved positive. The Wassermann reaction was negative. A diagnosis of lymphgranuloma inguinale was made.—*Audrey G. Morgan.*

RENANDER, AXEL. Roentgenologic features of tuberculosis of the rectum. *Acta radiol.*, 1941, *22*, 367–370.

A case of tuberculosis of the rectum in a woman of forty-three is described. She had had violent straining at stool for several weeks. The stools were mixed with much mucus and some blood. There was no pain. She had lost some weight. Roentgen examination showed annular infiltration of the rectum for a distance of about 10 cm. with nodules in the mucous membrane. In spite of this extensive infiltration, however, the rectum showed good power of contraction. This proved that the muscularis propria was functioning and that therefore the infiltration, though extensive, was not deep. This is a valuable point in differentiating between tuberculosis and cancer or syphilis of the rectum.

No focus was found in the lungs or elsewhere so this was apparently a case of primary tuberculosis of the rectum, which is rare.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

RIDLON, G. R. Atypical pyelograms in cystic disease of the kidney. *J. Urol.*, Sept., 1941, *46*, 480–485.

The author presents 3 cases of cystic disease of the kidney, each of which had atypical pyelograms. The first case was that of a male aged fifty-one, who complained of pain and a mass in the left loin. Red blood cells were present in the urine. The pyelogram showed a cavity filled with medium in the upper pole of the left kidney and from this film a diagnosis of a degenerating carcinoma was made. Operation disclosed a cyst in the upper pole of the kidney which communicated with the renal pelvis through a small sinus. After evacuation of the cyst a pyelogram seventeen months later showed a normal pelvis.

The second case was that of a thirty-three year old white male who complained of irregularly recurring episodes of "smoky urine" for one year and frank hematuria for two days. A pyelogram showed a large collection of contrast medium in the upper pole of the right kidney and a diagnosis of hemorrhagic cyst was made. At operation a polycystic kidney was found containing hemorrhagic cysts.

The third case was that of a fifty-eight year old white woman who had no kidney complaints. A routine urogram showed a lesion suggesting a solitary cyst of the right kidney. The author made a diagnosis of hydrops of the gall-bladder of the pyelogram. Operation disclosed a solitary cyst of the kidney.—*R. M. Harvey.*

WILLIAMS, E. ROHAN. Pyelo-renal backflow. *Brit. J. Radiol.*, Sept., 1941, *14*, 275–283.

In studying retrograde pyelograms roentgenologists sometimes see a backflow of the opaque medium. The backflow may be pyelovenous, pyelolymphatic, pyelotubular or pyelointerstitial (extravasation). Experimental work had been done on this pyelorenal backflow before the roentgen era but it was of only academic interest. With the introduction of pyelography, however, it became important clinically. In 1924 Hinman and Lee-Brown in studying the vascular anatomy of the kidney on celloidin-corrosion preparations proved that venous backflow resulted from multiple ruptures from the fornix calycis directly into the veins around the calyces. The anatomy of the venous and lymphatic drainage system of the kidney is discussed and a composite diagram given to illustrate the venous drainage of the kidney and the pyelographic appearances of the various forms of backflow. Pyelograms of illustrative cases are also given.

Experimental work on the subject is discussed. The only form of backflow that can occur without rupture of the calyces is the pyelotubular form. The venous and interstitial forms may be caused by injury of the walls of the calyces by the tip of the catheter, or even the force of the jet from the catheter tip during injection may cause rupture of the fornices. Even a slight degree of overfilling may be followed by venous backflow or minor degrees of extravasation. But even when the technique of pyelography is perfect pyelotubular and pyelolymphatic backflow may be seen. Tubular backflow is of no importance if a non-toxic substance is used for the contrast medium; lymphatic backflow suggests that there is some abnormal communication, congenital or acquired, between the lymphatic channels and the pelvis and calyces.—*Audrey G. Morgan.*

NOWELL, STANLEY. Increasing density of the renal shadow during excretion urography; a sign of acute ureteric obstruction. *Brit. J. Radiol.*, April, 1941, *14*, 138–143.

Three cases are reported which, in excretion urography showed increasing density of the kidney shadow during the examination. In 2 of them the calyces and pelvis could not be seen while in the third they were enlarged. In all the cases there was a stone in the ureter on the side of the increased density. Evidently the increasing density is caused by the contrast medium being concentrated in the kidney tubules as a result of pressure resulting from the damming up of the urine in the kidney pelvis. This finding therefore indicates that the kidney is functioning and in cases in which the kidney is suspected of not functioning it should be looked for. If present it proves kidney function. If there is known to be a stone in the ureter the increasing density indicates that the condition is in the acute phase. It may be the means of demonstrating the presence of a non-opaque stone in the ureter. In acute cases with abdominal pain on the right side, suggesting appendicitis it may be the means of making a differential diagnosis

and determining that the pain is caused by obstruction of the ureter.—*Audrey G. Morgan.*

Wyatt, George M. Excretory urography for children. *Radiology*, June, 1941, *36*, 664–671.

Disease of the urinary tract is not uncommon in children and is responsible for a considerable number of deaths. Pyelography is necessary for the early diagnosis of these conditions and descending urography is safer and less complicated and more physiological than the retrograde method. Directions are given for carrying out excretory urography in small children. Gas in the small intestine is the greatest obstacle to satisfactory urography up to the age of six or eight years and should be avoided by keeping the patient in the upright or prone position or on the right side. The supine position and that on the left side should be avoided. Fluids should not be too greatly restricted as it makes the children too uncomfortable and they cry, thus increasing the gas. Lack of concentration of the urine is best compensated for by increasing the amount of contrast material. Diodrast has been used as a contrast medium in more than one thousand cases at the Children's Hospital in Boston without any bad effects, though fatalities from its use have been reported in the literature. Dose for children under six months of age 10 cc., six months to two years 15 cc., two to five years 20 cc. and over five years 25 cc. If the child is too young to stand, one person should hold his shoulders and another his upper thighs to prevent the twisting motions characteristic of young infants.

The average technique for an infant six months of age calls for 65 kv., 200 ma., 1/20 sec., 36 inches target-film distance, Lysholm grid. Speed is so important that if a sufficiently short exposure cannot be made at the usual target-film distance it is better to decrease the distance than to increase the exposure time. First films are taken with the patient upright to avoid gas in the small intestine and later ones in the recumbent position to get optimum concentration of the dye. Films are usually taken five, fifteen and thirty minutes after injection of the dye in order to establish a standard for the comparison of cases.—*Audrey G. Morgan.*

Bowen, J. Andrew, and Shiflett, E. Lee. Intravenous urography in the upright position. *Radiology*, June, 1941, *36*, 672–677.

The authors carried out intravenous urography in the upright position on 19 persons, 12 females and 7 males. No preparation was given. The contrast medium was diodrast, 30 cc. A preliminary five minute film was made in the supine position, then films were made in the upright position after twenty, thirty-five and fifty minutes, then a final one in the supine position. Seven of the 19 persons, or 36.8 per cent, were found to have gross anomalies. One man had a bilateral hydronephrosis, 2 women bilateral ptosis and 4 women unilateral ptosis. The minimal descent considered ptosis was 5 cm. and the maximal 9 cm. In the cases with bilateral ptosis there was dilatation of the pelves. They believe these women with ptosis will be more liable to infection in later life, particularly in connection with child-bearing and that they will show a greater tendency to stone formation than women with their kidneys in normal position.

The calyces, pelves and ureters were not so well defined as in the prone position which the authors believe is due to increased peristalsis in the upright position. They conclude that kidney abnormalities are more common than is generally believed. They do not think that abnormal roentgen signs without clinical findings should be considered an indication for surgery.

In the discussion it seemed to be the opinion that these cases of ptosis are not of special importance and that the reason for the poorer visualization of the urinary tract was simply gravity rather than increased excretion. *Audrey G. Morgan.*

Thomas, Gilbert J., Stebbins, T. L., and Sandell, Samuel T. Roentgenology of renal tuberculosis. *Radiology*, June, 1941, *36*, 678–683.

The authors have examined 7,700 patients from a private clinic in a large metropolitan area and a 700-bed county sanatorium which admits patients with all types of tuberculosis. Among 4,199 patients from this group whose records were complete 4.1 per cent had tuberculosis of one or both kidneys. The plain roentgenogram of the kidney is of little value in the diagnosis of early tuberculosis. It is useful in about 25 per cent of advanced cases. Even excretory urography is not decisive in the diagnosis of early tuberculosis; if it is negative retrograde pyelography must be performed in order to exclude the disease definitely.

If a patient has bone tuberculosis careful

examination should be made for tuberculosis of the kidney. Associated tuberculosis of the bones and joints and of the kidney is the most frequent combination of lesions resulting from the hematogenous spread of the disease from the lungs. Not only is urographic examination of value in the diagnosis of kidney tuberculosis but the progress of the disease and the effect of treatment can be followed up by means of serial pyelograms. If sinuses remain after the surgical removal of a kidney their course can be shown by a roentgenogram taken after the injection of an opaque suspension into them.

In the discussion Dr. Kornblum emphasized the importance of the urologist and roentgenologist appreciating the limitations of excretory urography. When a kidney tuberculosis can be diagnosed by descending pyelography it is no longer early. Roentgenologists particularly should pay more attention to this subject and should make a more thorough study of urology. —*Audrey G. Morgan.*

RENANDER, AXEL. Another case of spontaneous rupture of the renal pelvis. *Acta radiol.*, 1941, *22*, 422–424.

The author has previously described a case of rupture of the kidney pelvis by a stone and called attention to the rarity of such cases. In this article he describes a case in a woman of sixty-three who was admitted to hospital for severe pain in the left side of the abdomen and straining on urination. Roentgen examination showed the pelvis of the left kidney slightly distended, with relatively bulky calyces. The contrast fluid did not pass into the ureter normally but settled like a coating around the lower pole of the kidney and formed an irregular deposit on the median side of the pole. Evidently it had passed out through a rupture in the pelvis. Operation showed the rupture but did not show any stone, so the cause of the rupture is not known.

In this case the outlines of the psoas muscle were normal both in the roentgenogram and in the intravenous and retrograde pyelograms. The perinephritic changes had evidently not developed to such a degree as to obscure the outlines of the psoas. The perforation was judged to have taken place one day before the examination. In the previous case the outline of the psoas was obliterated and it was estimated that the perforation had taken place two days earlier.—*Audrey G. Morgan.*

WILLIAMS, E. ROHAN. Subcapsular rupture of the kidney—case report. *Brit. J. Radiol.*, July, 1941, *14*, 248–249.

A case of subcapsular rupture of the kidney is reported in woman of thirty-one who was knocked down by a motorcycle. She showed hematuria for four days after the accident but improved steadily and was discharged well one month after admission.

Plain films of the urinary tract on the fifth day after the accident showed general enlargement of the right kidney shadow. Excretion urography immediately afterward showed the upper calyces normal on the right side but the lower ones could not be defined. Forty-five minutes after the injection a vague opacity was seen at the lower pole of the right kidney apparently caused by extravasated urine but it gave little definite information in regard to the injury of the kidney. The next day a retrograde pyelogram was made. The contrast medium passed out from two ruptured calyces and collected in a puddle, the lower and lateral margins of which corresponded exactly to the lower outline of the kidney. The retrograde pyelogram showed exactly the site, nature and degree of the rupture.—*Audrey G. Morgan.*

ROBERTSON, T. D., and HAND, J. R. Primary intrarenal lipoma of surgical significance. *J. Urol.*, Sept., 1941, *46*, 458–474.

The authors found in the literature 12 intrarenal lipomas of such significant size as to be removed surgically. They add 2 new cases. Normally there is no fat in the kidney. Therefore the presence of a fatty tumor must be due to embryonal rests or fatty metamorphosis of multiplying perivascular and intertubular connective tissue cells. Intrarenal lipomata are to be distinguished from perirenal lipomata and replacement lipomatosis in a pyonephrotic kidney shell.

The first case reported by the authors was in a white female, aged twenty-nine, who complained of severe left loin pain, vomiting and localized tenderness. A left pyelogram showed an enlarged kidney with an elongated isthmus to the upper major calyx. The preoperative diagnosis was renal tumor. Histopathological examination of the tumor mass which was removed at operation showed a lipoma encroaching on kidney tissue with no intervening capsule.

The second case was that of a white female,

aged forty-eight, who had had no symptoms referable to the affected kidney. A left pyelogram showed elongation of the left kidney pelvis with lateral and caudad displacement of the kidney. A preoperative diagnosis of left renal tumor was confirmed at operation by the presence of a large lipoma in the upper pole. There was, as in the first case, no capsule separating the tumor from the kidney parenchyma.

The authors review the cases previously reported in the literature. These cases must be differentiated from renal cancer and this can only be done histologically. The prognosis is good in intrarenal lipoma.—*R. M. Harvey.*

Bugbee, H. G. Exploration of certain renal tumors. *J. Urol.*, July, 1941, *46*, 1–16.

Nephrectomy is the one cure for any type of renal tumor. This depends on an early diagnosis, which may be very difficult to make. Pain, hematuria and tumor are the classical symptoms and to them may be added urographic irregularities. Defects in the urogram which may simulate tumors are spasm of the pelvis or calyces, calculus, blood clot, air bubbles, mucus plugs, pus and caseous débris in the renal pelvis, deformities secondary to pyelonephritis, tuberculosis and pyonephrosis, renal carbuncle, cysts, torsion of the kidney, anomalies, extra-renal tumors and perinephritic abscess. The urogram should be repeated frequently in doubtful cases. In many cases surgical exploration is warranted where tumor cannot be ruled out.

The author cites illustrative cases of renal tumors with a paucity of clinical symptoms but evidence of some irregularity in the urogram. In each case operative interference revealed the true nature of the lesion. It is interesting to note that although clinical and cystoscopic findings may often be negative there is usually some defect in the urogram which arouses suspicion.

In cases with definite large inoperable renal tumors preoperative irradiation will often cause such marked reduction in the size of the tumor that later operation is possible.—*R. M. Harvey.*

Bugbee, H. G. Tuberculoma of the kidney; report of a case. *J. Urol.*, Sept., 1941, *46*, 355–358.

The patient was a white woman, aged thirty-five, who entered the hospital with chief complaints of frequency and dysuria and a history of gross hematuria and dull lumbar ache. Roentgen examination of the chest revealed no evidence of tuberculosis. A catheter could only be passed 1 cm. up the left ureter and the bladder urine contained acid-fast organisms which resembled the tubercle bacillus morphologically. Excretory urograms showed a normal right kidney and a filling defect suggestive of tumor in the left kidney. At operation the left kidney was removed and when split the pelvis was filled with a firm pinkish mass resembling a renal tumor.

Histological examination showed multiple discrete tubercles throughout the kidney and a tuberculoma in the renal pelvis. No necrosis or cavity formation had occurred. The authors were unable to find a case report of tuberculoma of the kidney in the literature.—*R. M. Harvey.*

Fowler, H. A. Bilateral renal ectopia; report of four additional cases. *J. Urol.*, June, 1941, *45*, 795–812.

Renal ectopia means a congenitally misplaced kidney with an anomalous blood supply. This condition must be distinguished from a ptotic kidney which has wandered from its normal position but has a normal blood supply. Fixation of the ectopic kidney helps to distinguish it from the ptotic kidney which is freely movable. The commonest surgically important anomalies of the kidney are horseshoe kidney, renal ectopia, crossed ectopia with and without fusion, and anomalies of rotation.

Renal ectopia may be unilateral, bilateral or crossed. In crossed ectopia one kidney is displaced to the opposite side and lies below its mate with or without fusion to its mate. Its ureter recrosses the midline and enters the bladder in the normal manner.

Bilateral renal ectopia is the rarest anomaly. The author found 36 previous case reports which, in addition to his 4, brings the total to 40. He reviews the previous literature and adds case reports of his 4 cases. Films of retrograde pyelograms and intravenous urograms are included to illustrate the anomalies.

The predominant clinical symptom is pain, which varies in intensity and suggests low abdominal pain rather than urinary tract pain. Symptoms of disease in an ectopic kidney are misleading due to the anomalous position of the kidney. The anomaly is not productive of pain unless associated disease is present.

Intravenous urography and pyelography are essential for a preoperative diagnosis. Treatment is the same as for the similar disease in a normally situated kidney.—*R. M. Harvey.*

HYAMS, J. A., and KENYON, H. R. Localized obliterating pyelonephritis. *J. Urol.*, Sept., 1941, *46*, 380–395.

The authors describe unusual changes which do not conform to the changes previously described in pyelonephritis. These changes are of an obliterative type, limited to one or more calyces and resulting in destruction of the calyx or its isolation from the true pelvis by a cicatricial barrier. The cause is extension of the infection to the submucosa. The authors were able to trace the development of these changes in several cases. They include several case reports with urograms to show the early changes which may lead to obliterative phenomena.

The characteristic urographic changes are loss of terminal indentation of the calyx, irregular contour, contraction of the lumen of the infundibulum and decrease in the diameter of the terminal portion of the calyx. Successive pyelograms will show increasing stenosis and shortening of the infundibulum with eventual disappearance of the calyx. Retrograde urography is necessary to demonstrate these changes.

Differentiation must be made from hydrocalyx, calyceal diverticulum and isolated tuberculous lesions.—*R. M. Harvey.*

PATERSON, RALSTON. Cancer of the bladder. *Brit. J. Radiol.*, July, 1941, *14*, 219–234.

Cancer of the bladder is relatively rare but it often occurs in young subjects and is an industrial disease of considerable importance.

There are various types of bladder cancer histologically but from the point of view of treatment the author thinks it preferable to use the macroscopic classification into benign papilloma and non-infiltrating and infiltrating cancer. Roentgen diagnosis can be made by simple cystography but he discusses a method, still in the experimental stage, called the relief pneumocystogram, which he thinks will prove valuable. Air, combined with a small amount of fluid but adhesive emulsion, is used to get a mucous relief picture. Illustrative cystograms and pneumocystograms are given.

The author believes that cancer of the bladder should be added to that group of cancers in which radiotherapy rather than surgery is to be considered the treatment of choice in all cases. Treatment may be either by implantation of radon seeds or radium needles or by radical deep roentgen treatment. The decision as to the kind of treatment to be used should be made before the bladder is opened. Radium should be used in small, solitary and well circumscribed growths and roentgen irradiation in multiple or large lesions. The decision should be made in advance because if roentgen irradiation is to be used the bladder should not be opened and if radon or radium implants are to be used the radiologist should stand with the implants in hand ready to apply them as soon as the bladder is opened. Diagrams showing the proper distribution of the implants is given. The dosage should be between 6,000 and 7,000 r. Seeds should never be implanted cystoscopically but the bladder should always be opened.

In roentgen treatment large doses should be given through small fields and a special mechanical method of directing the narrow beam should be used. Diagrams of the beam director and of the treatment fields are given.

Not enough cases are yet available for definite statistical reports but at the Holt Radium Institute, Manchester, 60 five year cases treated with intravesical radium are available. Of these 11 are alive and 10 of these are well and free of symptoms. Much more might be accomplished if early cases were treated. Of 64 three year cases 33 per cent are alive; of these 33 were early cases with a survival of 58 per cent and 31 late cases with a survival of 7 per cent. Of 17 two year cases treated with roentgen irradiation alone 5 are alive, well and free of symptoms.

Benign papillomata can be cured by a four-day twice daily course with full beam direction and a tumor dose of over 3,600 r. Another method of which the author has hope is the Chaoul contact or low voltage short distance therapy. The applicator can be fitted into the bladder and a single dose of 2,500 r given. The results in the few cases in which this method has been used have been good.

If radiotherapy is to be substituted for surgery in cancer of the bladder, radiologists must strive for perfection of technique and give up the old idea that radiotherapy is only palliative.—*Audrey G. Morgan.*

GREENFIELD, HENRY. Distant metastases from carcinoma of the urinary bladder. *Radiology*, Aug., 1941, *37*, 181–185.

Very few metastases from cancer of the bladder that could be demonstrated clinically or by roentgen examination have been reported because they generally occur late and in a large

percentage of the cases the patient dies from infection of the urinary tract before such metastases have had time to develop. Among 68 recorded cases of cancer of the bladder seen in the radiotherapy department of the Kings County Hospital there were 3 in which there was definite clinical and roentgen evidence of distant metastases. The author has seen another case in his private practice.

The histories and roentgenograms of these 3 cases are given. In 2 the metastases were in the lungs and in the third in the bones, involving both sides of the pelvis. The occurrence of metastasis does not depend on the size of the tumor or the degree of infiltration. Metastasis generally occurs by way of the blood rather than through the lymphatic system.—*Audrey G. Morgan.*

Clancy, F. J. Neoplasm complicating diverticulum of the bladder. *J. Urol.*, Sept., 1941, *46*, 486–490.

There have been only 50 cases of primary cancer occurring in diverticula of the bladder. The author adds an additional case in an eighty-three year old white male whose chief complaint was hematuria. A cystogram showed a large diverticulum arising from the right lateral bladder wall within which there was a filling defect suggesting tumor. At operation there was no evidence of carcinomatous invasion of the bladder wall although a malignant growth was found in the large diverticulum. The histopathological diagnosis was malignant papilloma.

The interesting feature of this case is that the diagnosis was suggested from the cystogram. The usual diagnosis by cystoscopic examination could not be made because of prostatic obstruction which prevented introduction of the cystoscope.—*R. H. Harvey.*

Collings, C. W., and Welebir, F. Osteoma of the bladder. *J. Urol.*, Sept., 1941, *46*, 494–498.

The authors were able to find no case reports in the literature back to 1916 of osteoma of the bladder. Their case was that of a sixty-seven year old colored female who complained of frequency, burning and dribbling of six years' duration and hematuria of three months' duration. Just prior to the onset of her symptoms she had received radium and deep roentgen therapy for a carcinoma of the cervix. A survey film of the bladder area showed several round calcified bodies suggesting calcifications in fibroid tumors of the uterus. Through a suprapubic incision six bony masses which were stuck to the bladder mucosa were removed. The histopathological diagnosis was probable osteoma of the bladder.

The authors offer as a possible etiological factor thrombosis of the blood vessels of the bladder secondary to the previous irradiation for cervical cancer. The patient was free from bladder symptoms one year following the operation.—*R. M. Harvey.*

Strauss, B. The roentgen demonstration of the prevesical spaces. *J. Urol.*, Sept., 1941, *46*, 520–527.

The technique of the author in demonstrating the prevesical spaces is to prepare the suprapubic region as for cystotomy. The skin, underlying tissues and peritoneum down to the bladder were anesthetized with novocaine. The bladder was catheterized, lavaged with sterile water and then filled to capacity with sterile water and the catheter clamped. A 21 gauge, 3 inch hypodermic needle was then introduced into the bladder in the midline just above the pubis. As soon as the needle entered the bladder it was withdrawn until its point rested just outside the bladder. The bladder was then emptied and 30 cc. of diodrast introduced slowly through the hypodermic needle into the prevesical space. A survey film was exposed centering over the bladder. Then the bladder was filled with air and an air cystogram made. Various combinations of films were made in several positions. No complications occurred. The solution could be demonstrated in the kidney pelves in thirty minutes and was totally absorbed in one hour.

The author describes minutely the anatomy of the prevesical spaces. The various appearances which may be assumed by the injected medium in the prevesical spaces are demonstrated by films. The three main areas which could be demonstrated by this method are the retropubic, preperitoneal and perivesical.—*R. M. Harvey.*

Katzen, P. Metastatic carcinoma of the epididymis; report of a case. *J. Urol.*, Oct., 1941, *46*, 734–739.

Only 2 cases of metastatic carcinoma to the epididymis have been reported in the literature. These 2 cases both had their primary site in the kidney. The author adds an additional case which occurred in a white male, aged forty-one,

who was admitted to the hospital complaining of upper abdominal pain, nausea and vomiting. He had lost 27 pounds in six weeks. Gastrointestinal examination revealed a large carcinoma in the pyloric end of the stomach, which was confirmed at operation. The histopathological diagnosis was colloid adenocarcinoma of the stomach. Three months later he was readmitted with a painless swelling of the right side of the scrotum. On physical examination the right epididymis was enlarged and hard. The right vas was also thickened and hard.

At operation an enlarged firm epididymis was removed. The histopathological report was metastatic adenocarcinoma.—*R. M. Harvey.*

HERGER, C. C., and SAUER, H. R. Relationship of serum acid phosphatase determination to presence of bone metastases from carcinoma of prostate. *J. Urol.*, Aug., 1941, *46*, 286–302.

Many cases of carcinoma of the prostate show bone changes which often cannot be definitely stated to be metastatic. Frequent examinations to note changes in the appearance of the lesions may be necessary before a positive diagnosis can be made. Recent work suggests that the phosphatase activity of the blood serum may be of diagnostic and prognostic value. The authors routinely examine the pelvis, lumbar spine and chest for evidence of prostatic cancer. Recently they have been making phosphatase determinations.

The enzyme phosphatase liberates phosphate ions from phosphoric acid esters. The authors use the method of King-Armstrong rather than that of Bodansky. Gutman and Robinson have shown that phosphatase was increased in 37 out of 44 cases of carcinoma of the prostate with metastatic bone changes regardless of whether the changes were of the osteolytic or osteoblastic type. No elevation of blood phosphatase occurred in the absence of metastases. This was acid phosphatase as opposed to increase in alkaline phosphatase which occurred in Paget's disease. They set an arbitrary value of 3.0 units with the King-Armstrong method as the limit. If the phosphatase exceeded this value metastases were probable even in the absence of visible bone changes and if the value was below this level metastases were unlikely even in the presence of suspicious bone changes.

The authors have attempted to determine the reliability of the acid phosphatase determinations as indicators of bone metastases in cancer of the prostate. One hundred patients were examined, 69 with cancer of the prostate and 28 controls. Three cases were in doubt. Thirteen cases had definite bone metastases and every case had acid phosphatase values above the arbitrary 3.0 units, the average being 22.24 units. In 9 of the 13 cases alkaline phosphatase was also increased. They found no distinction in phosphatase values in osteolytic and osteoblastic types of metastases. In 19 of the remaining 87 cases values above 3.0 King-Armstrong units were found. Four of these cases had areas suggesting metastases in the pelvis. Nine cases had cancer of the prostate with no evidence of metastases. The authors do not feel that Gutman, Gutman and Robinson are justified in setting their arbitrary figure of 3.0 King-Armstrong units as top normal. They suggest 4.0 units for this value. They also believe that the findings should show a tendency to rise on repeated examinations if definite bone metastases are present. They had only one patient with definite bone metastases and a normal acid phosphatase determination.

In conclusion, the authors believe that the acid phosphatase values of the blood serum are of definite diagnostic aid in metastatic bone lesions from carcinoma of the prostate. Values below 4.0 King-Armstrong units should be considered normal. Values from 4.0 to 6.0 units should be interpreted with caution. They feel that values above 6.0 units indicate metastatic bone involvement from cancer of the prostate. A rapidly progressing elevation of the acid phosphatase activity should be regarded as an unfavorable prognostic sign.—*R. M. Harvey.*

SEAMAN, J. A., and BINNIG, C. Urological complications of cancer of the rectum. *J. Urol.*, Oct., 1941, *46*, 777–787.

Cancer of the rectum can be palpated by rectum in 85 per cent of cases. This is of interest to the urologist who makes use of rectal palpation more often than the other specialists. The close relationship of the rectum and urinary tract render the latter vulnerable to rectal cancer and the operative measures connected with it. The ureters may be traumatized, ligated or sectioned in abdominoperineal operations on the rectum. The sympathetic or parasympathetic nerve supply may be injured, producing an atonic bladder with relaxed sphincter. The bladder usually suffers severe trauma in being separated from the rectum. Bladder in-

fections are a frequent sequel to rectal operations.

Cancer of the rectum rarely invades the prostate gland. Occasionally rectal cancer may invade the bladder. Usually the symptomatology of the primary lesion will overshadow the symptoms of a secondary obstructive uropathy.

After operative removal of the rectum for cancer it is no longer possible to make an early diagnosis of prostatic cancer by rectal palpation. This raises the question of the advisability of doing a routine prostatectomy in rectal cancer although no disease of the prostate may be present.—*R. M. Harvey.*

SKELETAL SYSTEM

Howes, William Edward, and Schenck, Samuel George. Roentgenologic considerations in the diagnosis and treatment of primary malignant bone tumors. *Radiology*, July, 1941, *37*, 18–34.

The authors present a study of 40 primary malignant bone tumors. They were, according to Ewing's classification, osteogenic sarcoma 24 cases, chondrosarcoma 3 cases, endothelioma 5 cases, multiple myeloma 3 cases, reticulum-cell lymphosarcoma 4 cases, unclassified 1 case. The age range of the patients was from two and one-half to seventy-two years, the average being 32.6 years. The average duration of symptoms before the beginning of treatment was about six and one-half months.

Roentgen examination proved to be one of the surest methods of diagnosis. Roentgenograms of illustrative cases with descriptions of the typical findings in the different forms of tumor are given. Among the 39 cases examined roentgenologically the diagnosis proved correct in 33. One case was diagnosed as osteochondroma instead of osteochondrosarcoma, 1 as metastatic malignancy instead of lymphosarcoma, 1 as metabolic dyscrasia instead of leukosarcoma, in 1 no roentgen diagnosis was ventured but it proved to be reticulo-endothelioma, 1 was diagnosed as cortico-periostitis of the ulna but proved to be angio-endothelioma, and in 1 case of parosteal osteogenic sarcoma the roentgenograms taken postoperatively proved negative.

Treatment cannot be standardized at present. Among these cases 35 were given irradiation or operation or both. Twenty-six patients were benefited for from one month to four and one-half years, including the 13 still alive, giving a mean average of 15.4 months' alleviation of symptoms. The other 9 showed no clinical improvement from either surgery or irradiation. Up to the present time 25 of the patients are dead, 2 have not been followed and 13 are living. The present survival period in these 13 cases, dating from the beginning of treatment, is from three months to six years, the mean average being twenty and one-half months.

In the discussion Dr. Murphy said that the usual classifications of bone tumor are pathological but he thinks that pathological diagnosis is just as difficult as roentgenological. It should be remembered that anteroposterior and lateral views are often not sufficient. Stereoscopic, tangential and other types of views should be made to bring out all possible information. If such care is taken he thinks the roentgenologist will be as successful as the pathologist in diagnosis.

Dr. Newell said that either irradiation or surgery may fail. A Ewing tumor might be cured by either irradiation or amputation and the patient die from remote metastases. This does not prevent his preferring irradiation for Ewing's tumor.

In closing Dr. Howes said that the danger from biopsy was slight as compared with its value in diagnosis. Brailsford advocates immobilization of the limb and follow-up examinations when diagnosis cannot be made from the original examination. Dr. Howes thinks the danger from delay is greater than that from biopsy.—*Audrey G. Morgan.*

Campbell, Willis C., and Hamilton, J. F. Gradation of Ewing's tumor (endothelial myeloma). *J. Bone & Joint Surg.*, Oct., 1941, *23*, 869–876.

Campbell and Hamilton state that the available literature contains no record of an attempt to grade Ewing's tumor. So a serious study was made of 30 cases, particularly with reference to microscopic findings of the tumors, in an effort to find reliable data which would aid in grading the malignancy of this entity. They regard the grading of this tumor, as of carcinoma and sarcoma, as exceedingly difficult. A number of factors are responsible for this difficulty, especially the total lack of differentiation of the tumor cell. The prognosis, therefore, should always be guarded.

They conclude that the most significant of their findings is the nuclear chromatin content,

and the cell activity as measured by the number of mitotic figures per high-power field. A classification of the tumors according to their chromatin content indicates that those containing a large number of chomatin knots are probably more malignant than those containing a lesser number.

In studying the cellular activity, they divided the tumors into three grades, according to the number of mitotic figures in a high-power field, as follows: Grade 1, one to five figures; Grade 2, six to ten figures; and Grade 3, eleven to fifteen figures. It appeared that a patient with a tumor having five or less mitotic figures (Grade 1) has approximately a 23 per cent chance to survive ten years and a 31 per cent chance to live five years, whereas, if the mitotic count is eleven or above (Grade 3), he will probably live little over a year. None of the patients with tumors in Grade 2 of the series lived ten years, and 3, or 33 per cent, lived over five years.

The roentgenographic evidence presented by their cases indicated that the early stage, characterized by bone condensation, goes hand in hand with increased cellular activity, whereas late bone changes are usually accompanied by diminished cellular activity.

They regard this group of cases as too small to draw any definite conclusions regarding the gradation of Ewing's tumor. Studies of large numbers of cases may throw more light upon the subject and lead to the discovery of a method of establishing a more accurate prognosis.—*R. S. Bromer.*

AITKEN, A. P. Roentgenographic recognition of synovioma. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 950–952.

The tumor which was present in the case reported by Aitken was one that is derived primarily from the cells of the synovial lining, and which is characterized by the formation within the tumor of spaces lined with synovial cells. The tumor is said by pathologists to resemble closely an angioma, and is often mistaken for it. This neoplasm is a sarcoma, and is either highly malignant or potentially so. Although the tumor is derived from synovial cells, and may thus arise from either a joint or bursa, it may be found to be entirely extracapsular, and to have no apparent association with either of these structures. However, it is usually found in close proximity to a joint.

Lewis has described the roentgenographic appearance as follows: "Near a joint, and sometimes involving the joint, is seen a rounded, sometimes rather lobulated, sharply defined, soft-tissue tumor mass. No differential diagnosis can be made on such a mass itself; but when in the mass is found a scattered and irregular deposit of amorphous lime, we have learned that a provisional diagnosis of synovioma is justified." Aitken's case showed in the roentgenograms of the knee joint amorphous areas of calcification with definite extension into the joint space and with no evidence of bone involvement. His patient was operated upon and the tumor was removed, but sixteen months later examination showed multiple metastases to the lungs.—*R. S. Bromer.*

KIBBY, SYDNEY V. Melorheostosis, with report of a case. *Radiology*, July, 1941, *37*, 62–67.

Melorheostosis is a type of hyperplasia of bone limited to one extremity and extending from one end of it to the other but usually leaving a few unaffected areas along its course.

The author reviews the few cases previously published and describes a case of his own in a Japanese girl, five years old when first reported in 1931. Illustrative roentgenograms are given. The patient had difficulty in walking and some valgus deformity of the knee. The onset had been gradual. She had had slight pain in the knee at times. The child had been late in starting to walk and had a slight limp. Roentgenograms showed linear areas of increased density extending from the head of the left femur along the medial and anterior surface of the shaft to about a quarter of an inch above the distal epiphysis. There was spotty condensation in the patella and the upper epiphysis of the tibia. A streak of condensation extended down the lateral and anterior surface of the tibia to the lower epiphysis. The fibula was not involved. There were areas of condensation in the astragalus and traces in the os calcis, navicular and first metatarsal. There appeared to be arrested development of the epiphyses of the involved bones. Six years later roentgenograms did not show any increase in the extent of the lesions or any changes in their distribution.

The cause of the condition is not known. Zimmer's theory that it is due to a congenital developmental defect in a primitive segment explains the distribution and the early occurrence of most of the cases but does not account for the disease in adults.—*Audrey G. Morgan.*

CAMP, JOHN D., and MCCULLOUGH, J. A. L. Pseudofractures in diseases affecting the skeletal system. *Radiology*, June, 1941, *36*, 651–663.

Pseudofractures occur in various forms, either as transverse zones of decalcification, cracks or fissures extending through the cortex to one side or as fusiform callus formation and periosteal reaction. They seem to develop without gross trauma but trauma may convert them into true fractures. Attempts have been made in recent years to show that these pseudofractures constitute a new and independent disease entity. The author does not believe that this is true as they occur in many conditions that are not closely related. The greatest number of cases were reported in the years immediately following the world war, indicating that in some cases at least they are caused by malnutrition. The author concludes that they are caused by excessive strain on bones that are already weakened by disease. They occur most frequently in the bones that are subjected to the greatest strain. Experimental work has been done that seems to confirm this theory.—*Audrey G. Morgan.*

HART, VERNON L. Two unusual injuries of the wrist. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 948–949.

Hart records two unusual injuries of the wrist resulting from direct violence over the volar aspect of the carpus. The first injury is a fracture of the ridge of the greater multangular bone or trapezium which gives attachment to three of the intrinsic muscles of the hand and the transverse carpal ligament.

The second injury which he describes is a scar-tissue ring constricture of the ulnar nerve where it passes over the hook of the hamate or unciform bone which forms a part of the ulnar border of the carpal canal. Excision of the ring of scar tissue and a neurolysis of the affected portion of the nerve resulted in complete relief of the patient's disability.—*R. S. Bromer.*

CARTER, RALPH M. Carpal boss: a commonly overlooked deformity of the carpus. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 935–945.

Carter's first patient presenting the condition known as "carpal boss" was a woman, aged thirty, who had a definite rounded tumor on the posterior aspect of the right wrist situated at the base of third metacarpal bone. It was firm in consistency, was painless upon pressure, and was apparently firmly attached to the underlying bone. The skin was freely movable above it. The tumor was approximately 1 cm. in diameter and was much more apparent with the hand in extreme palmar flexion. A lateral roentgenogram showed that the tumor was a definite outgrowth of bone posteriorly from the distal articular surface of the os capitum of the wrist, and a similar outgrowth from the proximal surface of the third metacarpal; in other words, there seemed to be a fully developed posterior "lipping" of the articular surfaces of both bones, with complete preservation of the articulation itself. The patient was operated upon and the condition found at operation was that shown in the roentgenogram. The spurs were removed and the symptoms disappeared. Within a few months the tumor had reappeared, and the roentgenogram revealed that the preoperative condition had recurred. However, there has been no recurrence of symptoms and the tumor, having again attained its original dimensions, has since shown no tendency to increase is size.

Carter has seen 5 more patients with the same condition. Investigation of the literature showed that the process was a definite clinical entity, but one which apparently has only been described in the French medical literature. The causes assigned to the process are speculative, and it has not been sufficiently studied to prove or disprove the various etiologic theories. The fact that the deformity always occurs in the same location, and that it always presents the same roentgenographic appearance, would indicate that some etiologic factor is present which is common to all; as, for instance, it would appear extremely likely that this common factor might be an occupational one. However, a study of Carter's cases would seem to indicate that the various occupations of his patients had nothing in common, which would tend to disprove this suggestion. That the cause which originally produced the condition probably remained active is shown by the fact that the exostoses promptly recurred after removal.

Carter states that two considerations prompted his report. In the first place, the disease is of interest from the academic standpoint. It is apparently a sharply defined clinical entity, and probably more common than a search of the literature would indicate. Even though it is a comparatively trivial affection, orthopedic surgeons should have it in mind and be able to recognize it when it presents itself, if only for the purpose of differential diagnosis.

In the second place, and probably of more importance from a practicable standpoint, is the fact that disability claims may arise following industrial accidents, as in one of his patients. In the published cases and in Carter's own experience, there is nothing to indicate that the condition follows a single trauma in the affected region. On the contrary, it appears to be a gradual development.

He believes that these patients should not be operated upon.—*R. S. Bromer.*

CAVE, EDWIN FRENCH. Retrolunar dislocation of the capitate with fracture or subluxation of the navicular bone. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 830–840.

Dislocation of the capitate bone, with fracture or subluxation of the navicular, has been third in frequency in the series of carpal bone injuries at the Massachusetts General Hospital. It is, however, far outnumbered by fractures of the navicular bone and dislocations of the lunate. Reduction of the dislocation of the capitate by manipulation can be accomplished if done early. If this is not successful, open reduction must be carried out. If there is an associated navicular fracture, and satisfactory alignment of the fragments is not obtained by manipulation, Cave advocates open reduction and insertion of a bone graft. In neglected cases of this type of injury, he advocates a choice of treatment between excision of the first row of the carpus and wrist fusion.—*R. S. Bromer.*

SOTO-HALL, RALPH, and HALDEMAN, KEENE O. The conservative and operative treatment of fractures of the carpal scaphoid (navicular). *J. Bone & Joint Surg.*, Oct., 1941, *23*, 841–850.

The authors conclude that success in the treatment of fractures of the carpal navicular depends upon the recognition of the fracture within two or three weeks of injury, and upon adequate and prolonged immobilization. Under these favorable conditions osseous union may be anticipated in a very high percentage of cases.

Excision of one or both fragments of the navicular is reserved for a limited number of cases, including those showing marked comminution and those in which other measures have failed.

From further experience in the operative treatment of non-union, they believe that the drilling operation has a limited value, and that a procedure is indicated which combines the excision of the interposed fibrous tissue, the drilling of the bone, and the insertion of a bone graft from the radius. This procedure materially reduces the period of necessary immobilization and increases the chances of union.—*R. S. Bromer.*

SACHS, MAURICE D., HILL, HAROLD A. and CHUINARD, ELDON L. Further studies of the shoulder joint with special reference to the bicipital groove. *Radiology*, June, 1941, *36*, 731–735.

The usual roentgen projections fail to show bone changes in the region of the bicipital groove. The authors suggest a projection with the central ray tangential to the bicipital groove. The angulation varies with the thickness of the patient but medially it is approximately from 25 to 30 degrees and ventrally from 10 to 15 degrees. The patient is supine with the arm adducted and supinated; the cassette is on top of the shoulder and at right angles to the longitudinal axis of the humerus, the tube slightly external to and below the elbow.

Such views were made of 40 patients with a history of trauma to the shoulder but in whom routine roentgenograms were negative. The grooves were not normal in any of the cases. Four of the cases are described and illustrated with roentgenograms to show the nature of the abnormalities found. It will require further study and correlation of the clinical and roentgen findings to determine the clinical significance of these roentgen changes.—*Audrey G. Morgan.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 MARCH, 1943 No. 3

CONTENTS

Newer Aspects of Cancer Research. Caldwell Lecture, 1942 . . . . . C. P. RHOADS, M.D. 289

Million Volt Roentgen Therapy for Intrathoracic Cancer: Palliative Effects in a Series of Sixty-three Cases . . . . . WILLIAM L. WATSON, M.D., F.A.C.S., AND JEROME URBAN, M.D. 299

Post-irradiation Stricture of Rectum and Sigmoid Following Treatment for Cervical Cancer . . . . PALMER E. WIGBY, M.D., F.A.C.R. 307

The Effect of Roentgen Rays upon the Growing Long Bones of Albino Rats. II. Histopathological Changes Involving Endochondral Growth Centers . . . . . CHARLES L. HINKEL, M.D., MED. SC.D. 321

Contributions of Roentgenology to the Diagnosis of Chronic Constrictive Pericarditis . HAROLD J. STEWART, JOHN R. CARTY, AND JOHN R. SEAL 349

The Diagnosis of Congenital Heart Lesions in Children . . . . . G. W. GRIER, M.D. 366

Leiomyosarcoma of the Stomach . . . . . CLINTON G. LYONS, M.D., AND MARTIN SCHNEIDER, M.D. 393

Melorheostosis; Report of a Bilateral Case . J. W. J. CARPENDER, M.D., D. R. BAKER, M.D., S. P. PERRY, M.D., AND TOM OUTLAND, M.D. 398

Hemophilic Arthritis; Roentgenographic Studies in Fifteen Adult Patients with Hemophilia . . . . . EUGENE J. MCDONALD, M.D., AND EUGENE L. LOZNER, M.D. 405

Editorials

Roentgenography as a Diagnostic Aid in Pulmonary Fat Embolism . 410

Harry Myrrel Stewart, 1876–1942 413

John Watson Cathcart, 1877–1942 415

Society Proceedings, Correspondence and News Items 417

Department of Technique

Roentgenography of the External Ear . . . . . ARTHUR W. FUCHS, Major, Sanitary Corps 420

Abstracts of Roentgen and Radium Literature 424

GENERAL INFORMATION

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publishers.



Cornelius Packard Rhoads
Caldwell Lecturer, 1942

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 MARCH, 1943 NO. 3

NEWER ASPECTS OF CANCER RESEARCH

CALDWELL LECTURE, 1942*

By C. P. RHOADS, M.D.

Director, Memorial Hospital for the Treatment of Cancer and Allied Diseases; Professor of Pathology, Cornell University Medical College

NEW YORK, NEW YORK

THE honor done me in being asked to give the Caldwell Lecture before this Society is three-fold. First, I am not a roentgenologist, and hence to be asked to address a group of individuals so eminent in this field is an unusual tribute. Second, the career of the man in whose memory the lectureship is named was such that to be a guest speaker is a recognition of scientific accomplishment. And lastly, the willingness of this Society to hear a consideration of the physiological aspects of cancer is an indication of the importance of those aspects and of their application to our understanding of neoplastic growth.

It has seemed wise to confine this presentation to a consideration of the evidence which concerns the relationship of sex hormones to cancer. This is, of course, only one aspect of modern developments in the study of neoplasms, but one so important, and to which radiology has added so much, that it should be of vital interest to this group.

The phenomenal increase in knowledge concerning the biological effects of the sex hormones has raised, in recent years, very important questions concerning the possibility of their participation in the causation of cancer. It is desirable, at this time, to review the evidence which has been advanced in justification of these questions. This should be done in order to ascertain if possible (1) whether sex hormones play any rôle in the etiology of cancer in man, and (2) whether the induction of a hormone imbalance is at all useful in the treatment of any neoplasm.

It is clearly understood that the primary interest of physicians is in the problem of cancer in human beings. Apart from esoteric interest, investigative work in the cancer field is only important if it bears directly on that problem. As concerns the topic under discussion, however, experiments on animals provide so great a scientific background that it is neither just nor feasible to omit a discussion of them.

The first major step in the development of our knowledge concerning breast cancer came with studies of the genetics of that disease in mice. Through the work of a number of laboratories, notably those of Slye, of Little, and of Lynch, pure strains of mice were developed by persistent close inbreeding. After a given number of generations of such genetic control the animals become chromosomally identical and are

* The Twenty-third Caldwell Lecture, delivered at the Forty-third Annual Meeting of the American Roentgen Ray Society, Chicago, Illinois, September 15–18, 1942.

known as homozygous. Their various physical traits can be expected to be reproduced regularly in their descendants. Whereas "sports" of different characteristics occasionally occur, in general the physical traits are remarkably constant. By these methods certain pure strains are established in which all the females, or a very large number of them, will spontaneously develop breast cancer. The disease is not identical in all respects with breast cancer in man, but it is a malignant neoplasm of the breast; it metastasizes, and kills the animal. For these reasons it serves as a very useful tool. Other strains of mice have been bred which never or very rarely develop mammary neoplasms. Pure strains of mice in which the expected susceptibility to spontaneous mammary cancer is known obviously provide for the worker in cancer research a tool as precise as are pure substances for the worker in the chemical laboratory.

It is commonly supposed that the genetic characteristic of suceptibility to mammary cancer in mice remains constant as long as the strain is kept pure. Only one serious question can be raised concerning this assumption. Bagg[3] has reported that he could increase very greatly the incidence of breast cancer in a pure strain of mice which normally have a low incidence of that disease. This was done by breeding the animals very rapidly and removing the young without allowing the mothers an opportunity to nurse. This obviously, however, does not alter seriously the basic premise that, under standard conditions, the expected rate of breast cancer in pure strains of mice can be predicted very accurately.

It is, of course, a matter of great interest to ascertain whether the anatomical structures in the breast of low-breast-cancer-incidence mice differ in any way from those of the high-cancer-incidence strain. Taylor[29] and Gardner, Smith and Strong[14] have examined the facts concerning this point. There does appear to be a real difference. In the cancer-resistant or low-incidence strain C57, very slight development of acini is seen on the simple duct system of the resting breast. In the DbA, or high-incidence mice, myriad buds of epithelial cells are seen in the duct system even in the resting breast. As will be shown later, it is these acini which develop into masses of cells and under proper stimuli become transformed eventually into cancer cells.

As stated previously, the susceptibility to breast cancer in mice is clearly hereditary. More detailed studies, however, particularly those of Little[26] and his co-worker, Murray, proved clearly that the trait was not inherited as a simple Mendelian dominant. This became so clear that geneticists began to speak of the "extra-chromosomal genetic factor." Further studies showed that this factor was transmitted by the maternal parent. For example, if a female mouse of a high cancer strain was bred to a male mouse of a low cancer strain, the offspring had a high incidence of cancer. Conversely, if a female of a low cancer strain was bred to a male of high cancer strain, the offspring had a low incidence of cancer. Were the inheritance of the tendency to mammary cancer one which proceeded by the Mendelian law, the offspring of such crosses would be expected to have an intermediate incidence. This was not the case, but rather the genetic constitution of the mother seemed to exert the predominant influence.

This led to a most interesting and dramatic experiment. Bittner,[4] of Little's laboratory, foster-nursed mice born of a high cancer strain on mothers of a low cancer strain. If this foster nursing took place in the first twenty-four hours of the life of the infant mouse, the animal, in spite of its heredity, had a low incidence of cancer. In other words, in order that mice have a high incidence of breast cancer, they must be nursed by mothers of a high-incidence strain, quite independent of their inherited chromosomal pattern. This was a fundamental observation of the greatest importance. At first Bittner did not believe that the converse held; that is, that young mice of a low-incidence strain

would develop a high incidence of breast cancer if foster-nursed on high-incidence mothers. More recently, however, Andervont,[1] of the National Cancer Institute, has shown that if new-born mice of three low-incidence strains are foster-nursed by mice of strain C3H with a very high incidence of breast cancer, the incidence of the disease in the fostered animals can be raised from 0 to approximately 15 per cent.

Important as is the milk principle, so-called, transferred by the nursing mother to the young, it is not the only factor concerned in the inheritance of the tendency toward breast cancer in mice. Furthermore, the milk influence does not seem to bear on other forms of mouse cancer. Hence, the genetic work may be summed up in the statement that the tendency to breast cancer in mice depends upon two factors, one inherited and one contained in the maternal milk, and is associated with anatomical characteristics of the affected organ.

The next important development in our knowledge of experimental mammary cancer concerned the participation of endocrine function. This was originally suggested by the observation that the incidence of the disease was much higher in breeding mice than in virgin animals. This led Lathrop and Loeb,[23] and later Cori,[7] to examine the effect of removal of the ovary in mice of a high-incidence strain. It was found that oophorectomy early in life regularly prevented the development of breast cancer. Non-breeding control mice of the same strain had an incidence of 78.5 per cent. If the operation was done at between two and three months of age, the incidence of cancer was reduced, but the disorder was not eliminated entirely. It was also clear that the ovarian effect applied only to genital cancer, since certain of the animals developed neoplasms of tissue other than the breast. From the studies of ovarian removal, it was clear that some secretion of that organ played a significant etiological rôle in the cause of mammary cancer.

The next experiment followed naturally. If removal of the ovary with consequent loss of its hormonal secretion inhibited breast cancer in genetically highly susceptible animals, it was reasonable to try the effect of transplanting ovarian tissue into castrated male mice of a strain of which the females show a high incidence of breast cancer. This was done by Murray, and after some preliminary failures was successful. Breast cancer occurred in the male animals.

At about this time it became clear that ovarian function is under the control of the anterior pituitary gland. If the pituitary was removed, the ovary atrophied, and if fragments of pituitary were transplanted into closely related animals, the ovary was stimulated into excessive activity.[25] This led logically to the next experiment in the series: the transplantation of anterior pituitary into female mice of a high-cancer-incidence strain. When this was done, cancer occurred more frequently and earlier than in control animals. This effect only occurred, however, if the ovary was present.

In view of the successful experiments in which pituitary gland was transplanted, it was reasonable to try the converse: ablation of the pituitary in animals of a high-cancer-incidence strain. This, of course, cannot be done in very young animals, but if the operation is performed on adult mice, breast atrophy occurs; but the occurrence and growth of breast cancer is not inhibited.[12] This is difficult to understand except on the basis that the primary cancer-producing effect of the ovary under pituitary control has occurred before the pituitary can be removed. In other words, once the animal is of a suitable size for pituitary ablation, the damage which results in breast cancer has already been done.

Some years after the original experiments on ovarian removal and transplantation, Doisy, Thayer and Van Bruggen[9] published their classic experiments on the isolation in pure form of the effective principles of ovarian tissue. Three of these are now

known: estrone, estriol and estradiol. All of these are effective in inducing the development of secondary sexual characteristics in animals and, of course, are in common clinical use under various trade names. Once adequate quantities were available, it was reasonable to treat with them male mice of strains in which the females had a high incidence of cancer. This was done originally by Lacassagne,[21] and striking success was attained, but only in males of a high-cancer-incidence strain. No amount of treatment of males was effective if they were of strains of which the females normally would not develop breast cancer. This type of study has been confirmed and extended by Gardner. Of course, by the term "strain" is meant an animal bred from and nursed by mothers of the same strain. This is an important point because Twombly has proved that male mice of a strain which never develops breast cancer, foster-nursed on high-cancer-incidence mothers and then treated with pure female hormone, will develop breast cancer.

Examination of the effects of the injection of pure female hormone on the structure of breast tissue of male mice of low- and high-cancer-incidence strains is very interesting. This has been done by Taylor.[29] Thirty-seven thousand units of estrone given to a male mouse of a low-breast-cancer-incidence strain gives absolutely no morphological alteration of the breast structure. One-tenth this amount administered to a male mouse of a high-cancer-incidence strain gives very striking proliferation of the acini, with the formation of enormous numbers of buds of epithelial cells. It is quite apparent that the breast tissue of the two strains reacts entirely differently to female hormone. It must be said, however, that the clear-cut genetic difference may not apply to animals other than the mouse, since Geschickter appears to have evidence that the administration of estrogenic hormone to rats will cause breast cancer regularly and these animals never develop the disease. In the rat the pituitary gland is apparently required for the cancer producing effect of female hormone, since the tumor does not occur if the pituitary is removed surgically. Similar experiments have not been done with mice.

The clarity of the results concerning ovarian function as a cause of breast cancer led, of course, to the thought that inhibition of ovarian secretion or the antagonizing of that secretion by male hormone administration should inhibit the development of breast cancer. For this reason, the experiment was tried of administering testosterone to female mice of a high-breast-cancer-incidence strain. This was done by Lacassagne,[22] and also by Nathanson and Andervont.[27] It was partially successful inasmuch as, if the male hormone is given early in the life of the animal, breast cancer does not occur. This is not true, however, later in life, when male hormone administration seems to have little or no effect.

Now all this information can be summed up by the statement that spontaneous breast cancer in mice is caused by ovarian secretion (estrogen) given off rhythmically under pituitary control in mice predisposed to this disease hereditarily and by nursing. This is so clear that attempts have been made to correlate the tendency to breast cancer with sexual rhythm (Bonser[5]), the ability of the animal to destroy estrogens (Taylor and Twombly[30]), and the morphology of the glands of internal secretion such as ovary and adrenal[31] (Taylor, Gardner). Unfortunately, no absolute correlation has been proved to exist.

The fact should be noted, if only in passing, that breast cancer is not the only malignant neoplasm which can be caused in mice by the administration of pure ovarian secretion. In the hands of Gardner[13] and his co-workers, leukemia and cancer of the cervix have also resulted. Lipschütz and Iglesias[24] have proved that fibromas of the uterus and adnexa can be caused similarly in the guinea pig.

The certainty that ovarian secretion is concerned with the production of genital tumors in mice and other animals has, of course, led to a great deal of speculation as

to whether estrogenic substance has to do with the etiology of cancer in man. Since estrogens are administered frequently to a very large number of individuals and often in large amounts, we would suppose that, were they etiological, evidence of this fact would have been obtained by now. There is no clear-cut evidence. One case has been reported by Auchincloss and Haagensen[2] in which breast cancer certainly followed the administration of considerable amounts of estrogenic substance. The patient gave no suggestion of the presence of breast cancer before the treatment was begun. On the other hand, there was a strong history of mammary cancer in the patient's family, and if the occurrence of that disease was more than coincidental many instances would be expected to have occurred. They cannot be found, even though very careful surveys have been made.

The fact should be recalled that the amount of estrogenic substance given to mice in order to induce breast cancer is enormously greater than would ever be given to human beings. On the other hand, estrogens, when administered to monkeys and to rabbits in very large amounts, have not given rise to breast cancer. It seems probable that etiologically, at least, breast cancer in human beings is not caused by the administration of any pure substance which so far has been isolated from ovarian tissue. This is probably equally true of cancer of the uterus and cervix. Here, again, the disease, or anything simulating it closely, has never been produced in man or in primates, even though very large amounts of material have been given.

There is, on the other hand, some suggestion that estrogenic substances may play some rôle in the control of the rate of growth of breast cancer which has occurred spontaneously in human beings. This evidence first developed many years ago with the observation that oophorectomy in women with breast cancer was followed in some instances by rather striking, though temporary, regression of the disease. Since consistent results were not obtained, the procedure was abandoned. Later on, however, Dresser[10] studied the effect of inhibition of ovarian activity by roentgen irradiation in women with extensive metastasizing breast cancer. He felt that in about one-third of the patients treated while still of the menstruating age, very definite temporary regressions occurred, which would not have been expected to develop spontaneously. Some time later Taylor,[28] from the same clinic, reported similar observations, although he was even more certain than Dresser that little benefit was to be obtained by roentgen irradiation of the ovaries in women past the menopause. Nearly every clinic which treats patients with breast cancer has one or more examples of this phenomenon, a strong suggestion that in certain instances the removal of ovarian secretion is associated with a temporary cessation of growth of the tumor.

The experiments described were so striking, though irregular, that Farrow and Woodard[11] of the Memorial Hospital, were led to study the effect of the administration of male hormone on women with breast cancer metastatic to bone. They noted that pain appeared to be somewhat relieved, but on closer analysis discovered that the tumor appeared to extend more rapidly than if the testosterone were not administered. It was then observed that when male hormone, testosterone, or female hormone, estradiol, was administered to women with breast cancer metastatic to bone, the treatment was followed promptly by a striking rise in the levels of serum calcium. This was followed by a rise in serum phosphatase and by an increased output of calcium in the urine. The mechanism was quickly apparent. Either of the sex hormone sterols, estrone or testosterone, caused withdrawal of calcium from bone with resultant high serum levels of calcium and the loss of that mineral in the urine. This induced damage to bone was followed by attempted repair reflected by the increased phosphatase levels. When the same materials were administered to women with extensive breast

cancer not present in bone, no such effect was obtained. Furthermore, the effect, when attained, was associated with roentgenological evidence of extremely rapid extension of the neoplasm contained in the bony structures. It was perfectly apparent what was happening, since the results were open to only one explanation. The sex steroids stimulated enormously the rate of growth of the breast cancer tissue present in the bone, and this accelerated rate could be measured by the speed with which the tumor drove calcium out of the bone as well as by the speed with which bone destruction increased. These observations were clear-cut and led to an even more striking study. Two male patients with spontaneous breast cancer were at hand. In one of these the same experiment was tried as had been made with the women. An exactly similar effect was obtained. In the other, however, castration was done to remove one source, at least, of sterolic hormone. This patient has now been observed for a number of months, and the results have been dramatic. The tumor of the breast has almost completely disappeared and very striking healing of the areas of destruction due to the presence of cancer in the bone have taken place, exactly the reverse effect from that which would be expected to follow the administration of increased amounts of sex steroid.

More observations are, of course, required. We can only state at present that the removal of ovarian secretion does benefit certain patients with breast cancer, and that the administration of that secretion tends to make the disease much worse. This appears to hold for either sex.

The evidence which has been presented concerning the possible participation of female sex hormone (the estrogens) in the cause of genital cancer in man and animals is supported by more recent observations concerning cancer of the prostate gland. The fact should be recalled at the outset of a discussion of this topic that shortly after the discovery by Doisy of the crystalline compounds responsible for the control by the ovaries of secondary sexual characteristics, workers of the Swiss school, notably Reichstein and Butenandt, isolated from testicular tissue a sterolic compound called testosterone, with which male characteristics could be produced in castrated animals. A comparison of the formula of testosterone with those of the estrogenic substances reveals a striking similarity. Moreover, the fact should be recalled that all of the sex hormones so far described are chemically extraordinarily like the cancer-producing hydrocarbons which have been isolated from tar.

The first step in our knowledge of the effect of male hormone, testosterone, on the activity of the cells of the prostate gland came with the observation of Kutscher and Wolbergs[20] that an enzyme capable of breaking down beta-glycerophosphate at an acid reaction (pH 5) was present in adult human and monkey prostatic tissue. The fact had been known for a long time that human and animal serum contained a phosphatase which was active on the alkaline side, but this was the first demonstration of an acid phosphatase. Alkaline phosphatase had been shown by a number of workers to increase in amount whenever the process of bone repair was in progress, the enzyme being called upon to make available phosphate deposition in bone structure as calcium phosphate. Shortly after Kutscher and Wolbergs'[20] observation on acid phosphatase, Gutman and Gutman[15] took up the study of that enzyme and showed that the prostatic tissue of infants contained very small amounts, but that as adult life was approached the activity of the enzyme increased. This, of course, provided the suggestion that the maturity of prostatic tissue could be correlated with the amount of acid phosphatase present in it. Somewhat later, Gutman and Gutman[16] showed that the small amounts of acid phosphatase present in the prostate glands of immature monkeys could be increased regularly by the administration of androgenic substance (testosterone), but no such effect followed

the administration of estrogenic substance. This observation substantiated previous studies, of which the results indicated that the immature prostate could be rendered mature by the use of androgens but not by the use of estrogens. Indeed, ample evidence was at hand that female hormone could render atrophic the prostate gland of animals in which, under the natural androgenic stimulation, it had reached normal size.

The close correlation between tissue acid phosphatase content and the amount of mature prostatic epithelium present suggested that in patients with widely disseminated prostatic cancer acid phosphatase might be present in the serum. This was found to be the case by Gutman and Gutman[17] and by Woodard and Higinbotham.[33] Moreover, the amount of metastatic prostatic cancer tissue could be correlated closely with the amount of acid phosphatase present in the serum. In other words, the greater the increase of the enzyme, the greater the metastatic involvement. The close correlation between acid phosphatase levels and the amount of prostatic cancer tissue available outside of the prostatic capsule suggested promptly that the level of acid phosphatase could be used as an accurate index of the effect of various procedures on the rate of growth and extension of prostatic cancer.

Huggins, in a consideration of methods for the treatment of benign prostatic hypertrophy, encountered the papers of White[32] and of Cabot.[6] These authors had reported many years ago that castration was followed by a decrease in the size of benign hypertrophied prostates in human beings. The procedure had fallen into disuse, however, and had been forgotten. Huggins and Clark,[18] by the use of extraordinarily ingenious experimental techniques, reopened the subject. In one set of experiments they isolated the prostate in dogs from the bladder and set up an arrangement whereby all of the prostatic secretion could be collected and measured. The rate of secretion provided a direct index of the effect of the administration of compounds on the secretory activity of the canine prostatic tissue. By the use of this technique they were able to show that prostatic secretion could be maintained in the castrated dog by the regular administration of testosterone propionate in amounts of 10 mg. daily. If, in the face of this constant administration of androgenic substance, stilbestrol was given, the prostatic secretory activity promptly dropped to zero. As the dose of female hormone was decreased the secretory activity slowly returned, only to be depressed again when a given level of female hormone was exceeded. This experiment, more than any other, provided convincing proof that the activity of the prostatic epithelium is completely under the control of the sterolic sex hormones.

Huggins also found that in the senile dog a benign cystic adenomatous hyperplasia of the prostate gland was not infrequently encountered. Whereas the prostate in the young normal dog rarely weighs more than 10 gm., glands which are the site of senile canine adenomatous hyperplasia often weigh as much as 50 to 150 gm. This type of disorder is not known to occur in any other species than the dog. Huggins assumed that it is the analogue of benign prostatic hypertrophy in man. He then repeated on senile dogs which were the subject of such a benign hyperplasia the experiments described on animals with normal prostates. As was the case with the normal gland, the administration of androgens increased the secretion of the hypertrophied organ and estrogen decreased the rate of cellular activity. Like the effect which followed the administration of estrogens, castration decreased secretion and was followed by very marked atrophy.

The results of these experiments set the stage for a trial on the cancerous prostate of the procedures which appeared to be effective in reducing the size of the benign adenomatous organ. As previously mentioned, an index of effect was at hand in the levels of the phosphatase in the serum of the patient affected with metastatic pro-

static cancer. Phosphatase measurements could be substituted for the measurements of prostatic secretory rate used in the experimental animal. If the serum levels of acid phosphatase increased, an increased activity of the metastatic prostatic tissue could be assumed. If the serum acid phosphatase level decreased, a decrease in rate of growth and activity of the prostatic cancer would be indicated. Similarly, if the serum alkaline phosphatase rose, it would be a sign of an increased rate of bone repair, as opposed to a diminution in repair processes if the alkaline enzyme became less.

Testosterone propionate was then given to 3 patients with extensive bone metastases from prostatic cancer.[19] A prompt rise occurred in the serum acid phosphatase in all 3 instances. From this observation it seemed clear that the disease had been made worse by an increase in the amount of available androgenic material. Conversely, when the patients were castrated, a procedure which supposedly was followed by a decrease in the amount of available androgens, the acid phosphatase dropped and stayed at low levels, whereas the alkaline phosphatase increased as an index of an increased rate of repair of the bone invaded by the metastasizing tumor. This effect was obtained so regularly that it seemed safe to conclude that castration resulted in a striking decrease in the activity of the metastatic prostatic tissue. This was associated, moreover, with a marked diminution of pain, decrease in size of primary and metastatic lesions, gain in appetite and sense of well-being, increase in blood levels, gain in weight and in some instances roentgenographic evidence of healing of bone lesions. Moreover, the administration of estrogenic substance effecting essentially a chemical castration was followed by equally good therapeutic results.

In Huggins' most recent publication, he reports a considerable number of patients who, following castration, have remained free of disease for over thirty months. About 25 per cent of his patients were not benefited, or were better for only a short time. In 5, whereas the primary tumor appeared to decrease in size, the metastatic lesions grew rapidly and were clearly quite out of control of the hormone effect. At the Memorial Hospital, Dean, Twombly and Woodard have examined the results of surgical castration in 45 patients and of chemical castration by stilbestrol administration in 12 more. Results have been obtained which parallel closely those reported by Huggins, although the patients have been followed for a much briefer time. Sharp decreases in levels of acid phosphatase, with subsequent increases in levels of alkaline phosphatase, have been caused quite regularly. In only a small number of patients, however, have striking changes in the extent of the primary or metastatic neoplasms been observed. The systemic effects have been quite as dramatic as those reported by other observers. At the present time, roughly 75 per cent of the patients treated are in relatively good condition. Twenty-five per cent either have died or are the subjects of recurrences.

On these patients careful determinations of the rate of excretion of androgens as measured by the output of 17-keto-steroids have been made concurrently with measurements of the output of estrogens by the biological assay method. Following castration, Dean and Twombly report, surprisingly enough, a rise in the output of androgens measured as neutral 17-keto-steroids (11 out of 17 instances). A similarly unexpected finding was a fall in estrogen output in almost every case (15 out of 16 examined). The fall was marked and averaged more than half of the preoperative level (18.8 m.u. to 8.5 m.u.). No explanation is now at hand which is sufficient to clarify the apparently anomalous result. Certainly an increased androgen output with a decreased estrogen output would not be expected to follow removal of a gland, the testicle, supposedly the source only of androgenic material.

Even more striking is the result on the rate of hormone excretion which Dean[8] and

his associates have found to follow the therapeutic administration of stilbestrol. Following the use of this compound, the clinical results are quite as good, if not better, than those which are a sequel to castration. After stilbestrol, in the 7 cases examined, the output of androgenic substance, as indicated by the 17-keto-steroid level, fell in every instance. This was in sharp contrast to the rise in the same component of the urine observed to follow castration. Equally anomalous are the findings as concern the output of pituitary gonadotropic hormone in the urine of the treated patients. Following castration, the amount of this hormone rose in 11 out of 16 instances, a finding which would be expected. After the administration of stilbestrol, however, there is a tendency to a fall. It is quite apparent that, chemically, castration is attended by quite different sequelae than is the administration of stilbestrol. The biological effect upon prostatic tissue appears to be similar. No adequate explanation of this interesting finding is now at hand. It can only be assumed that the therapeutic value of either procedure depends upon the feminization of the patient, and the more specific details of this action must await further study.

I have reviewed for you the salient experimental and clinical facts which bear at the present time on the question of the rôle of sex hormones in the production of cancer of the genitalia. It is clear that no etiological relationship can be clearly established in man between cancer and these important chemicals which we call endocrine secretions. The fact is equally clear, in my opinion, that sex hormones do have some influence on acceleration and retardation of the rate of growth of mammary and prostatic cancer. Even though we do not see, at the moment, the possibility of completely curative results to be obtained by the induction of a hormone imbalance in patients bearing genital cancer, the information which has been developed through patient, precise and ingenious animal and human studies has advanced enormously our knowledge of this difficult, indeed terrible, disorder. It is not too much to hope that equally patient and painstaking advances in the future will reveal even more significant information which will, in time, lead us to better understanding of the nature of the malignant neoplasm.

REFERENCES

1. ANDERVONT, H. B., The influence of foster nursing upon the incidence of spontaneous mammary cancer in resistant and susceptible mice. *J. Nat. Cancer Inst.*, 1940, *1*, 147–153.
2. AUCHINCLOSS, H., and HAAGENSEN, C. D. Cancer of the breast possibly induced by estrogenic substance. *J. Am. M. Ass.*, 1940, *114*, 1517–1523.
3. BAGG, H. J. Further studies on the relation of functional activity to mammary carcinoma in mice. *Am. J. Cancer*, 1936, *27*, 542–550.
4. BITTNER, J. J. Breast cancer in mice as influenced by nursing. *J. Nat. Cancer Inst.*, 1940, *1*, 155–168.
5. BONSER, G. M. A comparison of the normal oestrous cycle and of the response to the administration of oestrin in two strains of mice differing greatly in incidence of spontaneous mammary cancer. *J. Path. & Bact.*, 1935, *41*, 33–42.
6. CABOT, A. T. The question of castration for enlarged prostate. *Ann. Surg.*, 1896, *24*, 265.
7. CORI, C. F. Influence of ovariectomy on the spontaneous occurrence of mammary carcinomas in mice. *J. Exper. Med.*, 1927, *45*, 983–991.
8. DEAN, A., WOODARD, H. Q., and TWOMBLY, G. H. Endocrinologic treatment of prostatic cancer. In press.
9. DOISY, E. A., THAYER, S. A., and VAN BRUGGEN, J. T. Metabolism of the estrogens. *Federation Proceedings*, 1942, *1*, 202–207.
10. DRESSER, R. The effect of ovarian irradiation on the bone metastases of cancer of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *35*, 384–388.
11. FARROW, J. H., and WOODARD, H. Q. Influence of androgenic and estrogenic substances on the serum calcium in cases of skeletal metastases from mammary cancer. *J. Am. M. Ass.*, 1942, *118*, 339–343.
12. GARDNER, W. U. Persistence and growth of spontaneous mammary tumors and hyperplastic nodules in hypophysectomized mice. *Cancer Research*, 1942, *2*, 476–488.
13. GARDNER, W. U., KIRSCHBAUM, A., and STRONG, L. C. Lymphoid tumors in mice receiving estrogens. *Arch. Path.*, 1940, *29*, 1–7.

14. Gardner, W. U., Smith, G. M., and Strong, L. C. Stimulation of abnormal mammary growth by large amounts of estrogenic hormone. *Proc. Soc. Exper. Biol. & Med.*, 1935, *33*, 148–150.
15. Gutman, A. B., and Gutman, E. B. "Acid" phosphatase and functional activity of the prostate (man) and preputial glands (rat). *Proc. Soc. Exper. Biol. & Med.*, 1938, *39*, 529–532.
16. Gutman, A. B., and Gutman, E. B. Adult phosphatase levels in prepubertal rhesus prostate tissue after testosterone propionate. *Proc. Soc. Exper. Biol. & Med.*, 1939, *41*, 277–281.
17. Gutman, A. B., and Gutman, E. B. An "Acid" phosphatase occurring in the serum of patients with metastasizing carcinoma of the prostate gland. *J. Clin. Investigation*, 1938, *17*, 473–478.
18. Huggins, C., and Clark, P. J. Quantitative studies of prostatic secretion. II. The effect of castration and of estrogen injection on the normal and on the hyperplastic prostate glands of dogs. *J. Exper. Med.*, 1940, *72*, 747–762.
19. Huggins, C., and Hodges, C. V. Studies on prostatic cancer. I. Effect of castration, of estrogen and of androgen injection on serum phosphatases in metastatic carcinoma of the prostate. *Cancer Research*, 1941, *1*, 293–297.
20. Kutscher, W., and Wolbergs, H. Prostataphosphatase. *Ztschr. f. physiol. Chem.*, 1935, *236*, 237–240.
21. Lacassagne, A. Apparition d'adénocarcinomes mammaires chez des souris mâles traitées par une substance oestrogène synthétique. *Compt. rend. Soc. de biol.*, 1938, *129*, 641–643.
22. Lacassagne, A. Relationship of hormones and mammary adenocarcinoma in the mouse. *Am. J. Cancer*, 1939, *37*, 414–424.
23. Lathrop, A. E. C., and Loeb, L. Further investigation on the origin of tumors. *J. Med. Research*, 1919, *40*, 477–496.
24. Lipschütz, A., and Iglesias, R. Multiples tumeurs utérines et extragénitales provoquées par le benzoate d'oestradiol. *Compt. rend. Soc. de biol.*, 1938, *129*, 519–524.
25. Loeb, L., and Kirtz, M. M. The effects of transplants of anterior lobes of the hypophysis on the growth of the mammary gland and on the development of mammary gland carcinoma in various strains of mice. *Am. J. Cancer*, 1939, *36*, 56–82.
26. Murray, W. S., and Little, C. C. The genetics of mammary tumor incidence in mice. *Genetics*, 1935, *20*, 466–496.
27. Nathanson, I. T., and Andervont, H. B. Effect of testosterone propionate on development and growth of mammary carcinoma in female mice. *Proc. Soc. Exper. Biol. & Med.*, 1939, *40*, 421–422.
28. Taylor, G. W. Evaluation of ovarian sterilization for breast cancer. *Surg., Gynec. & Obst.*, 1939, *68*, 452–456.
29. Taylor, H. C., Jr. Endocrine aspects of chronic mastitis. *Surg., Gynec. & Obst.*, 1942, *74*, 326–342.
30. Taylor, H. C., Jr., and Twombly, G. H. Studies on the excretion of estrogens and androgens. In press.
31. Taylor, H. C., Jr., and Waltman, C. A. Hyperplasias of the mammary gland in the human being and in the mouse. *Arch. Surg.*, 1940, *40*, 733–820.
32. White, J. W. The present position of surgery of the hypertrophied prostate. *Ann. Surg.*, 1893, *18*, 152.
33. Woodard, H. Q., and Higinbotham, N. L. Serum and tissue phosphatase determinations as aid in evaluating radiation therapy of bone tumors. *J. Am. M. Ass.*, 1941, *116*, 1621–1627.

VOL. 49, NO. 3

MILLION VOLT ROENTGEN THERAPY FOR INTRATHORACIC CANCER

PALLIATIVE EFFECTS IN A SERIES OF SIXTY-THREE CASES*

By WILLIAM L. WATSON, M.D., F.A.C.S., *and* JEROME URBAN, M.D.
NEW YORK, NEW YORK

GREAT advances have recently been accomplished in the surgical treatment of neoplasms of the lung and esophagus and, at the present time, the treatment of early, primary, intrathoracic cancers is generally conceded to be surgical. Nevertheless, the majority of patients when admitted to Memorial Hospital are in an inoperable state, due either to dissemination of their disease, advanced age with general debility, or to a serious concomitant medical disease which precludes major surgical attack. It has been shown that approximately 26 per cent of cancers of the lung are resectable, and as high as 63 per cent of esophageal carcinomata explored have been resected. At Memorial Hospital, 26 patients with cancer of the esophagus have been surgically explored and 11 resected, a resectability rate of 43 per cent. Of 15 patients with carcinoma of the lung explored surgically only 3 were resected, a resectability rate of 20 per cent.

It is to be expected that the present campaign to promote the early diagnosis of malignant disease would result in the recognition of a higher percentage of intrathoracic cancers in an operable phase, but it must be realized that early symptoms are for the most part lacking and when the classical symptoms are present the disease is usually quite advanced. Roentgen therapy offers a logical form of therapy for the necessarily large group of inoperable cases.

It is difficult to obtain adequate tumor dosage in intrathoracic cancer by ordinary high voltage external roentgen irradiation because of the physical and physiological factors involved. Increasing the target-skin distance and using higher voltage and greater filtration makes it possible to deliver an adequate depth dose with less reaction in the intervening tissues and skin. The million volt roentgen-ray apparatus which has been in use at Memorial Hospital since 1939 delivers 52.4 r per minute (in air) at 1,000 kv. and 3 ma. at 70 cm. target-skin distance, with a filter of 2 mm. mercury, 2 mm. tungsten and 8 mm. copper, and a half-value layer of 3.8 mm. of lead. This set-up enables one to deliver a large dose to a deep-seated tumor without great permanent damage to the intervening structures. Hence, it would seem desirable to employ it in the radiation treatment of intrathoracic cancer.

Now, if one admits that the survival rate for cancer of the lung and cancer of the esophagus has been almost negligible by any form of therapy, it seems worth while to evaluate, if possible, the palliative effects of radiation therapy in these two diseases. It is the purpose of this report to study the effect of supervoltage roentgen therapy on patients with inoperable cancer of the lung and esophagus and to determine clinically, as far as possible, whether their symptoms have or have not been favorably influenced by treatment.

The small number of patients in this series and the limited time during which the million volt machine has been available for treatment of patients with intrathoracic cancer makes it inadvisable to attempt a broad evaluation of the possible long-range usefulness of this apparatus. It must be admitted that the post-irradiation results, so far, have not justified the initial enthusiasm engendered by the obvious theoretical and physical advantages of this relatively

* From the Thoracic Surgical Service, Memorial Hospital, New York. Presented at the Twenty-seventh Annual Meeting, American Radium Society, Atlantic City, N. J., June 8–9, 1942.

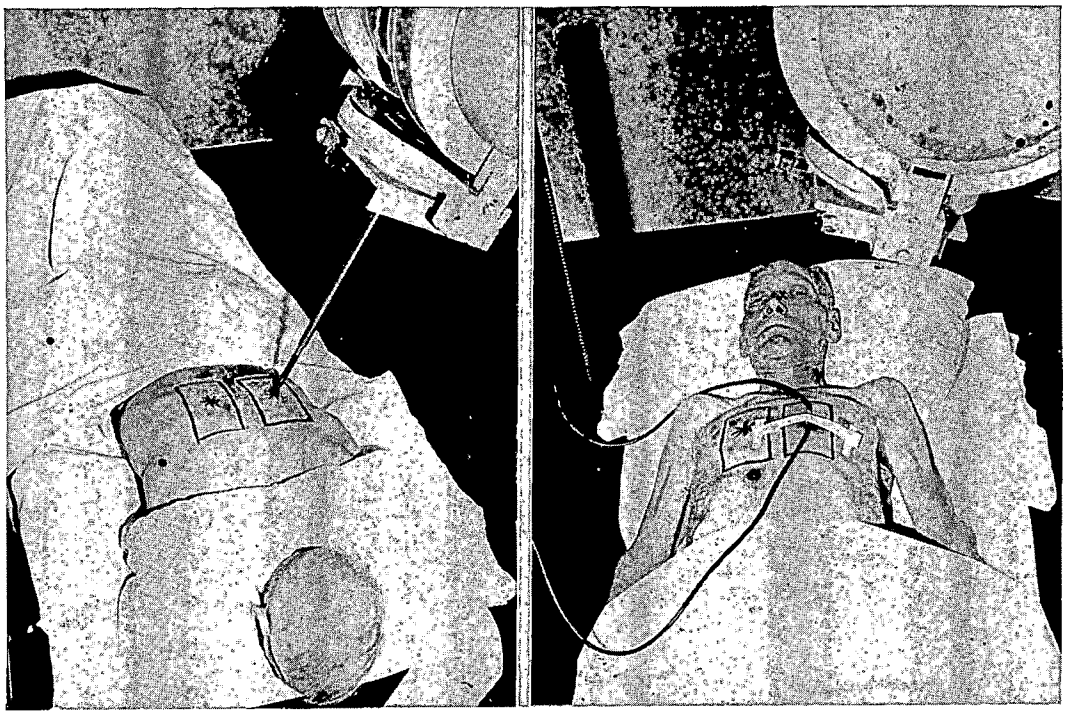


FIG. 1. Patient with cancer of the esophagus being treated with the million volt roentgen-ray machine. Portals have been outlined and the direction of the beam determined roentgenoscopically.

new form of radiation. On the other hand, certain advantages from a palliative point of view are noted, and it has been our aim to analyze the available data with a view to evaluating this form of therapy. The difficulty of impartial interpretation of the records is appreciated and a real effort has been made to evaluate fairly the patients' subjective reaction to supervoltage roentgen treatment.

TECHNIQUE

An effort was made to insure accurate treatment of all patients. Each patient was examined under roentgenoscopy in the position held during treatment and portals were outlined under direct vision (Fig. 1). In treating cancer of the lung, an attempt was made to center the beam on the primary tumor, not on the resultant atelectasis. Two portals, each with an average area of about 150 square centimeters, one anterior and one posterior, were usually employed. Most esophageal cancers were treated through four portals, each measuring 7 by 14 cm. A final check was made by exposing a roentgen film to the beam from the 1,000 kv. machine with the patient in position for treatment, thus outlining the tissues traversed by the direct roentgen-ray beam.

MATERIAL

Between August, 1939, and December, 1940, sixty-three patients with malignant intrathoracic disease were treated with the 1,000 kv. machine. None of these patients was considered to be operable at the time, but 8 had had previous exploratory thoracotomy. The group consisted of 33 cases of cancer of the lung, 21 cases of cancer of the esophagus, 3 cases of cancer of the lower esophagus and stomach. In addition, there was 1 thymoma, 1 advanced malignant giant cell tumor of the sternum, and 4 patients with pulmonary metastases.

CANCER OF THE LUNG

Of the 33 cases of pulmonary cancer, there were 30 males and 3 females. The ages ranged from thirty-four to seventy-

four years, the average age at onset of symptoms being 56.8 years. Statistical study is limited to the 27 cases with positive biopsies (Table 1).

Symptomatology. Symptoms in the order of frequency were cough, chest pain, loss of weight, hemoptysis and dyspnea. The earliest symptom noted most frequently was cough. Duration of symptoms before beginning therapy averaged 6.4 months (one to fourteen months) (Table 11).

Diagnosis. Twenty-four patients (89 per cent) had significant physical signs of pulmonary disease. Twenty-seven (100 per cent) showed significant pulmonary roentgen signs. The diagnosis was corroborated by positive tissue analysis by bronchoscopic biopsy in 59.3 per cent, by aspiration biopsy in 37 per cent, and by open thoracotomy and biopsy in 3.7 per cent. Each case in the series reviewed had a positive histological diagnosis.

TABLE I

CANCER OF LUNG—PATHOLOGY

	No. Cases
Epidermoid carcinoma	13
Lung carcinoma	8
Anaplastic carcinoma	4
Adenocarcinoma	2
Negative or uncertain	6
Total	33

Treatment. Twenty-seven proved cases of carcinoma of the lung were treated. Of these, 25 patients completed their outlined course of therapy and received a mean tumor dose of 4,400 r, varying from 2,200 to 8,800 r. Two patients were unable to complete their outlined treatment and received only negligible tumor doses. Symptomatic improvement of varying degree was noted in 22 cases (82 per cent) for an average duration of four months following treatment. Significant relief was indicated by a marked diminution in cough and chest pain (Table III).

Survival rate of the 23 deceased patients, excluding the 2 who received inadequate treatment, averaged 7.3 months since beginning roentgen therapy. Two patients with proved carcinoma of the lung are still alive with evidence of residual disease twenty-seven and twenty-nine months after onset of symptoms, and seventeen and nineteen months after beginning roentgen treatment. Unfortunately, almost all patients were treated in the Out-Patient Department and died at home, so that no postmortem examinations were possible in this group. Further analysis shows that a tumor dose of between 3,000 and 4,000 r produces the maximum palliative effect while a heavier dose, between 5,000 and 7,000 r gives the longest average post-treatment survival period.

TABLE II

CANCER OF LUNG—SYMPTOMS

	No. Cases	Per Cent
Cough	25	93
Chest pain	22	81
Weight loss	18	66
Hemoptysis	16	60
Dyspnea	15	56

CASE REPORT

Cancer of the Lung. A. I., white male, aged sixty-seven, storekeeper, born in Russia, was first seen at Memorial Hospital in July, 1940, at which time he complained of a chronic productive cough of seven months' duration, slight left chest pain, dyspnea and exertional palpitation of several weeks' duration, and hemoptysis on several occasions.

On physical examination, the patient appeared fairly well developed and nourished. Chest examination revealed diminished voice

TABLE III

CANCER OF LUNG—SYMPTOMATIC IMPROVEMENT FOLLOWING ROENTGEN TREATMENT

Symptom	No. Cases	Improvement Per Cent
General condition	27	82
Cough	25	64
Chest pain	22	59
Hemoptysis	16	19
Dyspnea	15	13

TABLE IV

CANCER OF ESOPHAGUS—SYMPTOMS

	No. Cases	Per Cent
Dysphagia	21	100
Weight loss	21	100
Pain	8	40
Vomiting	6	30
Hemorrhage	1	5

and breath sounds and a moderate amount of crackling râles at the left lung base. Roentgenogram of the chest revealed a dense, rounded shadow about 10 cm. in diameter in the left lower lung field. At bronchoscopy blood was noted in the left lower lobe bronchus, but no tumor was visualized. Aspiration biopsy of the lung mass was reported as "lung carcinoma."

Surgery was contraindicated because of arteriosclerotic heart disease. Roentgen therapy was given over a fifty-one day period beginning in September, 1940. He received 200 r (in air) ×22 to each of two portals, a posterior portal 11.5 by 14 cm. and a lateral oblique circular portal 11.5 cm. in diameter. Daily treatments were given to alternate portals. The total skin dose was 4,480 r×2 and the estimated tumor dose was 3,750 r.

Symptomatic improvement was noted about one month after therapy was begun. The cough decreased, patient felt stronger and gradually gained 20 pounds in weight. Hemoptysis ceased. Thirteen months after treatment was begun patient felt well but fatigued easily. He had no cough, no hemoptysis and no chest pain. Physical examination did not change materially. Râles and dullness persisted at the left lung base. Check-up roentgenograms revealed moderate radiation fibrosis and a diminution of the mass in the left lower lung to about 4 cm. in diameter. However, a later roentgenogram showed slight progression of the mass.

During November, 1941, the patient had several small hemoptyses and his cough again became troublesome. Another aspiration biopsy in December, 1941, was negative for tumor cells. Nevertheless, further therapy was deemed advisable and he received a second series of roentgen treatments for a total skin dose of 1,320 r×2 and an estimated tumor dose of 1,300 r. The factors were: 300 r (in air)×4 to each of two portals, a lateral circular portal 11.5 cm. in diameter and a posterior portal 11.5 by 14 cm. Daily treatments were given to alternate portals.

The patient had received a primary tumor dose of 3,750 r supplemented thirteen months later by a tumor dose of 1,300 r. In total, he received an estimated tumor dose of 5,050 r. This therapy was well tolerated by the skin.

One month following therapy, January, 1942, hemoptysis had ceased, cough was minimal, but the mass was essentially unchanged at roentgenoscopy. In March, 1942, twenty-seven months since onset of symptoms and nineteen months after beginning roentgen therapy, the subjective and objective signs were essentially unchanged.

CANCER OF ESOPHAGUS

Of 21 cases of squamous or epidermoid carcinoma of the esophagus, 20 were male and 1 female, a somewhat higher proportion of males than is usually found. The age on admission to the hospital varied from forty-six to seventy-five years and averaged 59.8.

Duration of symptoms before beginning roentgen therapy averaged 4.5 months (one to thirteen months). Dysphagia and weight loss were present in all patients at onset of therapy (Table IV).

Diagnosis. Physical signs were unsatisfactory. There was evidence of extreme weight loss in 17 patients (81 per cent). Enlarged involved lymph nodes were noted in 4 patients, and nodular enlargement of the liver was present in 5 patients. The diagnosis was corroborated by positive tissue analysis in all 21 cases by esophagoscopic biopsy. Roentgen studies were significant in 18 cases (86 per cent). All the esophageal lesions were intrathoracic; there

TABLE V

CANCER OF ESOPHAGUS—SYMPTOMATIC IMPROVEMENT FOLLOWING ROENTGEN TREATMENT

Symptom	No. Cases	Improvement Per Cent
General condition	20	55
Dysphagia	20	45
Pain	8	37
Hemorrhage	1	100

were no cervical cases in the series under discussion.

Treatment. Twenty proved cases of esophageal cancer were treated with the 1,000 kv. machine. Nineteen of these completed their outlined course of therapy and received a mean tumor dose of 4,300 r, varying from 1,200 to 8,100 r. One patient received a tumor dose of only 950 r; another patient of the original series died before any therapy was begun. In 12 patients dysphagia was so advanced that gastrostomies were necessary for feeding purposes before roentgen therapy was instituted.

Symptomatic improvement was noted in 11 patients (55 per cent) for an average duration of five months following therapy (Table v).

Survival rate of the 18 deceased patients, excluding 1 patient who received a tumor dose of only 950 r, averaged 4.4 months since beginning roentgen therapy. One patient is well, without evidence of residual or recurrent disease, more than thirty months since beginning roentgen therapy.

CASE REPORTS

Cancer of the Esophagus. E. F., white male, aged sixty-seven, Irish truck driver, was first seen at Memorial Hospital in October, 1939, at which time he complained of progressive dysphagia of six months' duration. He had lost 14 pounds in weight and had been able to swallow only liquids for the last two months.

Physical examination was essentially negative. Roentgenographic studies revealed a constriction in the lower third of the esophagus. At esophagoscopy a cauliflower-like mass was noted at a distance of 31 cm. from the alveolar margin. A biopsy was taken and reported as epidermoid carcinoma, Grade 2.

A Janeway type gastrostomy was performed November 15, 1939, under local infiltration anesthesia, and feedings were instituted. Surgical removal of the esophagus was suggested but was refused by the patient who appeared to be in good general condition. Million volt roentgen therapy was given during a treatment period of fifty-six days. The skin portals were outlined and direction of the roentgen-ray beam determined under roentgenoscopy. Later, during therapy, these portals were checked by a roentgen-ray plate exposed to the therapy unit with the proper diaphragm in position. The patient received 250 r (in air)×12 to each of four portals, each measuring 14 by 7 cm. with its long axis vertical. Daily treatments were given to alternate portals. The total skin dose was 3,300 r×4, and the estimated tumor dose was 4,800 r.

During roentgen therapy the dysphagia began to diminish and in September, 1940, eight months after completion of treatment, the patient was swallowing all foods without difficulty. Immediately after completion of roentgen therapy, the skin portals were moderately erythematous, but this gradually subsided and when the patient was last seen in April, 1942, no definite skin reaction was noticeable. Esophagoscopic examination during the late stages of roentgen therapy showed definite regression of the tumor mass and sharp reaction of the mucous membrane. The last esophagoscopy, November, 1941, showed some fixation of the lower third of the esophagus, granular mucous membrane, but no definite evidence of recurrence.

Roentgenographic studies three months after completion of therapy revealed moderate pulmonary fibrosis. The patient had had transient dyspnea for several weeks about three months after treatment. At present, he has no pulmonary symptoms.

At the present time, June, 1942, twenty-nine months after completion of therapy, the patient is well and has had no supplementary roentgen irradiation. His gastrostomy is still present, but is not used. This patient has no complaints; he is able to swallow all foods and has gained about 20 pounds in weight.

G. H., male, aged sixty-two, broker, was first seen at Memorial Hospital in August, 1940, at which time he complained of hoarseness, dysphagia and headache of three weeks' duration. He had lost 10 pounds in weight.

Physical examination revealed evidence of moderate weight loss. Multiple firm skin nodules were noted. Microscopic examination of one of these nodules revealed metastatic squamous carcinoma. Roentgenographic studies revealed evidence of a filling defect in the mid-esophagus. Esophagoscopic examination revealed an easily bleeding mass in the mid-esophagus. Tissue analysis was reported as epidermoid carcinoma.

During a treatment period of one month this patient received 300 r (in air) ×7 to each of four 16 by 8 cm. chest portals. In addition, an upper mid-abdominal portal of 14 by 14 cm. received 200 r×4. Estimated tumor dose was 4,050 r. Patient did not improve and died nine days after completing roentgen therapy.

Postmortem examination revealed multiple metastases to liver, right adrenal gland, lung, regional nodes, bones, skull and dura mater, and skin. Also, terminal pneumonia, acute negative endocarditis and emaciation. There was moderate erythema of the skin portals. The primary tumor site and adjacent lung and skin showed marked radiation reaction, and approached sterility. There was no gross effect of irradiation on other mediastinal structures adjacent to the primary tumor.

LUNG METASTASES

Several patients with pulmonary metastases have had million volt roentgen therapy with significant resulting palliation. Included among them were one patient with metastases from an adenocarcinoma of the rectum, another with metastases from a melanoma of the palate, a third with metastases from a granulosa cell carcinoma of the ovary, and a fourth with metastases from renal carcinoma.

CASE REPORT

M. M., female, white, single, aged thirty-two, of Scotch parentage, housekeeper, underwent an abdominoperineal resection for adenocarcinoma of the rectum in 1932. She had had preoperative roentgen irradiation of 1,350 r to each of four pelvic portals.

The patient was followed at regular intervals in the Out-Patient Department. Her postoperative course was uneventful until 1939 when she complained of a chronic, dry cough and occasional wheezing respirations. Physical examination at this time revealed a functioning colostomy, but showed no signs of pulmonary pathology. The pulmonary symptoms continued and a small hemoptysis occurred. Roentgenographic examination of the chest November, 1939, revealed an irregular mass in the left hilum. Bronchography showed incomplete filling of the anterior left lateral bronchus. At bronchoscopy a friable tumor mass was noted in the left lower secondary bronchus. A biopsy was obtained and reported as metastatic rectal adenocarcinoma, Grade 2.

Million volt roentgen therapy was begun in December, 1939, and completed during a fifty-five day period. The patient received 150 r (in air) ×24 to each of two portals, 8 cm. in diameter, over the anterior and posterior aspects of the left side of the chest. Daily treatments were given to alternate portals. The total skin dose was 3,800 r×2 and the estimated tumor dose was 3,500 r.

Bronchoscopy during treatment revealed marked regression. Following therapy the cough and hemoptysis ceased. However, two months later the cough recurred and the patient developed pain in the left side of the chest. Bronchoscopy revealed another lesion approximately 1.5 cm. in diameter on the posterior wall of the left main bronchus. A biopsy was reported as metastatic carcinoma.

A second cycle of roentgen irradiation was given three months later during a period of twenty-two days. The patient received 200 r (in air) ×10 to each of two portals, 11.5 cm. in diameter, anteriorly and posteriorly over the left chest wall. Daily treatments were given to alternate portals. The total skin dose was 2,200 r×2 and the estimated tumor dose was 1,950 r.

Cough diminished markedly and the patient felt much improved following the second series of treatment. Skin portals showed only a moderate erythema despite a total dose of 6,000 r to each portal. The left lower lobe was atelectatic and the mediastinum had shifted to the left. During the next few months the patient felt fairly well, gained several pounds in weight, but later had several small hemoptyses.

In October, 1940, roentgenographic examination revealed an atelectatic left lower lobe and a left hilar mass. At bronchoscopy a large friable mass was noted in the left main bronchus and a biopsy again was positive.

In late October and November, 1940, patient received additional roentgen irradiation; 300 r (in air) ×13 was delivered to one left oblique chest portal measuring 15 by 10 cm. She received one treatment daily for a total skin dose of 4,350 r and an estimated tumor dose of 2,150 r. Her symptoms decreased sufficiently for her to continue her usual work as a housekeeper. She felt well and gained weight.

The cumulative total estimated tumor dose was 7,600 r delivered in three courses over a period of eleven months from December, 1939, to November, 1940.

The patient had no significant pulmonary symptoms. However, at bronchoscopy Decem-

ber, 1941, a viable tumor was noted in the left bronchus. In January, 1942, roentgenographic evidence of bone metastases to the lumbar spine was present, and in February, 1942, further bone lesions appeared. Until February, 1942, with the aid of million volt roentgen therapy, this patient had been enabled to lead a useful and fairly comfortable life for a period of two years and ten months following symptoms of pulmonary metastases.

SUMMARY

1. Sixty-three patients with deep-seated intrathoracic cancer were treated at Memorial Hospital during 1940 with the million volt roentgen-ray machine.

2. Eighty-two per cent of the patients with cancer of the lung showed symptomatic improvement for an average duration of four months following treatment.

3. Fifty-five per cent of the patients with cancer of the esophagus showed symptomatic improvement for an average duration of five months following treatment. However, previously performed gastrostomies add to the difficulty of fairly judging the true roentgen irradiation effect.

CONCLUSION

It seems safe to draw a general conclusion that supervoltage roentgen therapy will play a definite rôle in the palliative care of patients with cancer in the thoracic cage, but so far this study does not lend encouragement to the hope that million volt roentgen therapy may lead to a high percentage of five year survivals.

REFERENCES

1. Bloch, R. G., and Bogardus, G. Bronchogenic carcinoma, with special reference to results with roentgen therapy. *Arch. Int. Med.*, 1940, *66*, 39–49.
2. Craver, L. F. Bronchiogenic carcinoma. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 469–478.
3. Craver, L. F. Diagnosis of malignant lung tumors by aspiration biopsy and by sputum examination. *Surgery*, 1940, *8*, 947–960.
4. Engelstad, R. B. Radiological treatment of carcinoma of esophagus. *Acta radiol.*, 1939, *20*, 469–488.
5. Farberov, B. E., and Baslow, E. A. Primary tumors of the lungs. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 701–713.
6. Frissell, L. F., and Knox, L. C. Primary carcinoma of lung. *Am. J. Cancer*, 1937, *30*, 219–288.
7. Garlock, J. H. Present status of surgical treatment of carcinoma of thoracic esophagus. *Am. J. Surg.*, 1941, *54*, 262–272.
8. Graham, E. A. Primary carcinoma of lung and bronchus. *Ann. Surg.*, 1936, *103*, 1–12.
9. Halpert, B. Morphologic aspects of carcinoma of lung. *Surgery*, 1940, *8*, 903–909.
10. Hammond, A. E. Diagnosis and treatment of carcinoma of lung. *Arch. Otolaryng.*, 1940, *31*, 780–807.
11. Hill, W. Radium therapy in cancer of oesophagus. *Brit. M. J.*, 1924, *2*, 1196–1197.
12. Körbler, J. Radium therapy of carcinoma of esophagus. *Strahlentherapie*, 1939, *66*, 219–223.
13. Macklin, M. T., and Macklin, C. C. Does chronic irritation cause primary carcinoma of human lung? *Arch. Path.*, 1940, *30*, 924–955.
14. Nielsen, J. Clinical investigation of radiation therapy of cancer of esophagus. *Acta radiol.*, 1940, *21*, 352–367.
15. Ochsner, A., and DeBakey, M. Surgical considerations of primary carcinoma of lung. *Surgery*, 1940, *8*, 992–1023.
16. Overholt, R. H. Carcinoma of lung as surgical problem. *Am. J. Surg.*, 1941, *54*, 161–172.
17. Overholt, R. H. Curability of primary carcinoma of lung. *Surg., Gynec. & Obst.*, 1940, *70*, 479–490.
18. Overholt, R. H., and Rumel, W. R. Clinical studies of primary carcinoma of lung. *J. Am. M. Ass.*, 1940, *114*, 735–742.
19. Portmann, U. V. Role of roentgen therapy in treatment of bronchiogenic carcinoma. *Cleveland Clin. Quart.*, 1940, *7*, 119–122.
20. Steiner, P. E. Effects of roentgen therapy on histologic picture and on survival in cases of primary carcinoma of lung. *Arch. Int. Med.*, 1940, *66*, 140–154.
21. Strandqvist, M. Transthoracic roentgen therapy of cancer of oesophagus. *Acta radiol.*, 1941, *22*, 172–193.
22. Vinson, P. P. Palliative treatment of carcinoma of esophagus. *Virginia Med. Monthly*, 1940, *67*, 144–146.
23. Watson, W. L. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1933, *56*, 884–897.
24. Wookey, H. Surgical treatment of mid-oesophageal carcinoma. *Brit. J. Surg.*, 1940, *27*, 696–705.

DISCUSSION

Dr. John E. Wirth, Baltimore, Md. I should like to congratulate the authors on the handling of a subject which I think is probably one of the most difficult we face today. I think they are to be congratulated for going ahead with this work when the prospects are so dark.

It is work that has to be done, work that should be done. Progress can be made and that progress is only going to be made by those institutions which have supervoltage therapy available and are willing to go ahead with the work and see what results can be obtained.

I agree with the general premise that all operable cases should be operated upon. One doesn't see many papers regarding operations on lung and esophagus, but they are being done more and more and in the next few years I think you are going to see a great number of papers on the subject. It is an expanding field. It also is a field in which there is a great deal of progress to be made.

The authors state that it is difficult to obtain an adequate tumor dosage in intrathoracic cancer by ordinary high voltage external irradiation because of the physical and physiological factors involved. Time undoubtedly precluded the possibility of going into these two factors to any great length so that I should like, if possible, to emphasize the second of these factors; that is, physiological factors.

A tremendous field is covered in the words "physiological factors." These not only play a part in ordinary high voltage roentgen therapy but also limit to a great extent adequate dosage with supervoltage roentgen therapy.

I would like to emphasize, as did the authors, the correct localization of the lesion. So many bad results, or lack of any results at all, I believe, are due to the fact that the treatment is not actually getting to the lesion. I think that perhaps intrathoracic lesions are the most difficult of all in which to accurately direct the therapy to the desired place.

Very recently we had a beautiful example of this difficulty. We had operated on a patient who had a low esophageal lesion. A steel clip was placed just below the diaphragm, so that we knew the exact location of the lower end of the esophagus. Two of us separately outlined the skin portals that we thought should be treated and then subsequently checked this with roentgenograms to show the clip in relation to the outlined portals. One of us missed centering the clip by 2 inches in one direction and the other missed by 2 inches in another direction.

I believe the authors should be complimented on the extensive number of biopsies they have obtained in their series of lung cases. I feel it is very important to have biopsies on all of these lung lesions; otherwise, our end-results are going to be of no value whatever in terms of palliation or cure. It is entirely too easy to confuse intrathoracic lesions such as lymphomas, primary tumors of the lung, and even nerve tumors within the pleural cavity.

If the bronchoscopic biopsy is not positive, I agree with the authors, by all means try an aspiration biopsy. I do not wish to bring up the subject of the advantages or disadvantages of aspiration biopsy but certainly in lung tumors it is of decided advantage to be sure that you are dealing with a neoplastic process. In many instances it is possible to distinguish a primary tumor of the lung from a lymphoma by aspiration biopsy.

It is interesting to note that the patients receiving the larger amounts of treatment gave the longest average post-treatment survival periods while doses of 3,000 to 4,000 r produced the maximum palliative effect. Perhaps the authors wish us to bear that in mind so that if we have a patient on whom we feel we wish the most palliation, perhaps we had better not go too high, whereas if we wish longevity we had better go to very high dosages. I don't know whether they had this idea in mind, but they certainly suggest it.

Previous gastrostomies add to the difficulty of fairly judging the true roentgen irradiation effects. It is very hard to judge the effects of irradiation on esophageal lesions if there is a coincident gastrostomy.

On the whole, no new or startling results have been produced by this series but it is encouraging,—it is something that makes us wish for more, makes us all wish that more could be done with these cases. No one can get away from that point of view if he has seen very many esophageal and primary lung tumors. The utter hopelessness of most situations when they are inoperable, and the desire to alleviate the suffering of these patients, we all appreciate.

I do not believe roentgen irradiation is going to be the final answer, but I think its use should be continued; supervoltage roentgen therapy should be continued for there is a great deal of progress to be made.

Dr. Urban (closing). I wish to thank Dr. Wirth for his excellent and thorough discussion, with which I agree. At the present time, further analyses of million volt roentgen therapy results are being conducted at Memorial Hospital.

Vol. 49, No. 3

POST-IRRADIATION STRICTURE OF RECTUM AND SIGMOID FOLLOWING TREATMENT FOR CERVICAL CANCER

By PALMER E. WIGBY, M.D., F.A.C.R.*
HOUSTON, TEXAS

ATTENTION has been called in a number of reports in the literature during the past ten or twelve years to the reaction of the bowel to high voltage roentgen and radium irradiation for cancer within the pelvis. The clinical picture and histogenesis of the bowel lesions, which occur chiefly within the rectum and sigmoid, are fairly generally recognized and understood. The limits of tolerance of the bowel to irradiation from which it will satisfactorily recover are not well defined, and very little work has been reported, to my knowledge, to determine how much irradiation the bowel can actually tolerate without permanent injury. It is not the purpose of this paper to attempt to define those limits because of the magnitude of the problems involved. It did occur to me, however, that some useful information might be gained by summarizing a series of cases in which the dosage was maximum and a relatively high percentage of bowel reactions occurred.

There are few reports in the radiological literature on the subject of post-irradiation proctitis and sigmoiditis. Some have appeared in other literature, chiefly surgical.[1,2,3] Corscadan, Kasabach and Lenz[4] included several cases of ulceration of rectum and sigmoid in their paper on intestinal injuries after radiation treatment, with one case well six years after colostomy, and one two years. They state the injuries apparently ceased following reduction in daily dose and size of fields for the roentgen treatment, and prolongation of the radium application. Buie and Malmgren,[5] on the other hand, reported rectal reaction following the use of 800 mg-hr. of radium in the uterus for fibromyomata. The filtration used is not mentioned. That individual susceptibility exists there can be little doubt. The "no reaction" cases tabulated in Table III suggest this rather strongly. A real challenge to the medical profession and its allied sciences lies in finding a reason for this variation. The answer should come from investigation within the field of radiobiology.

Severe irradiation reaction of the intestinal tract, chiefly within the sigmoid and rectum, occurred in at least 24 of the 100 cases on which this paper is based. Idiosyncrasy of the tissues to irradiation may have been present in many of these patients, although it is my opinion that large dosage was probably responsible for many of the reactions. Roentgen dosage has been reduced in our clinic but the cure rate will also probably decline. Colostomy was necessary to relieve critical symptoms of lower bowel injury in 6 of the 100 cases. Three others developed intractable diarrhea and died; 1, having ileosigmoidal fistula, died in the hospital, and the other 2 at home, declining further medical care. In spite of improved methods of treatment, cases of this type occur unexpectedly during and after treatment and may prove to be of more immediate consequence than the initial lesion for which treatment was instituted.

The general profession should be warned not to regard these complications as representing hopeless recurrence. Therefore, any physician seeing a patient with intestinal symptoms, especially if they suggest obstruction several months or even years after radiation treatment for any pelvic condition, should submit the patient to careful examination, which should include a com-

* Formerly, Director of Radiology, Parkland Hospital, Dallas, Texas.

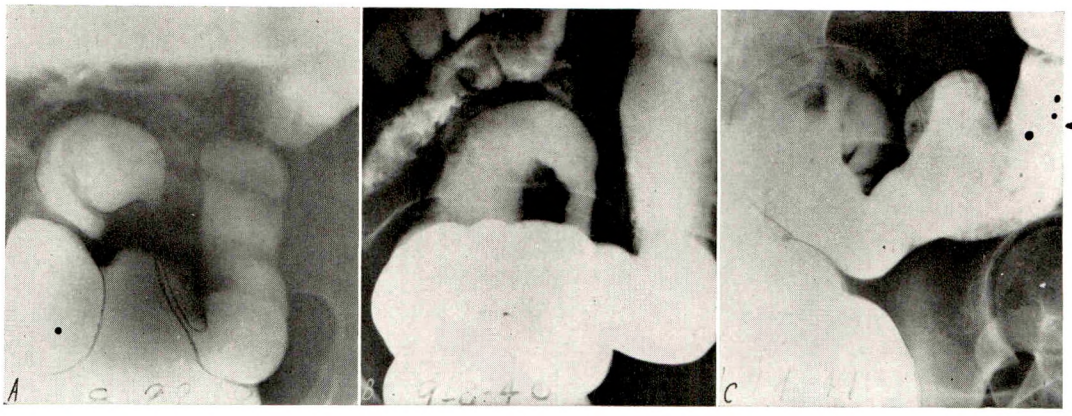


FIG. 1. Case 71. White, aged 34, para II, clinical Group II. Squamous cell carcinoma cervix Grade 3. External roentgen therapy between July 15, 1940 and August 21, 1940, 7,950 r—medium Thoraeus filter, intensity 25 r per minute. During same period for fourteen days, 360 r delivered daily through 4 cm. intravaginal cone, total 5,040 r. Factors for latter were 200 kv. (peak), 18 ma., 45 cm. distance and 0.25 mm. copper and 0.5 mm. aluminum. Intensity 72 r per minute. Mild bloody diarrhea began twelfth treatment day. Starch enemas and olive oil instillations. No radium treatment. Cervix appeared normal at time of complete hysterectomy October 7, 1940 (only case in series receiving this). Occasional small clots per rectum since. *A*, August 22, 1940, persistent narrowing proximal sigmoid. *B*, September 2, 1940, definite improvement. *C*, January 14, 1941, no abnormal change.

plete history, roentgenologic studies of the colon, and sigmoidoscopic examination, and if in doubt a biopsy should be taken. The diagnosis of benign irradiation stricture can readily be made by such means and a colostomy or resection of the stricture or a combination of the two procedures may restore the patient to essentially normal health. With newer plastic devices* (Fig. 4) for covering the colostomy, and with proper attention to diet, the colostomy itself, even if it should become permanent, does not present the difficult or unhappy aspects that it did in former years. Three patients who have had colostomies from eleven to eighteen months live an essentially normal life.

The bowel complications in this series of cases are tabulated in Table I. The intestinal reactions are divided into four groups. Those with no reaction; those with only diarrhea (first degree reaction); those passing blood with frequent loose stools (second degree reaction); those developing stricture necessitating colostomy (third degree reaction).

First degree reactions show hyperemia (often telangiectases) and bullous edema by proctoscopy, and it may be presumed the same type of reactions can occur anywhere in the intestinal tract included in the portals of treatment. This reaction usually begins during the third week of roentgen treatment, although it may occur months to years after completion of the irradiation. No particular treatment is necessary for this reaction, particularly if mild. Paregoric

* Designed by Dr. Tom E. Smith, proctologist, Dallas, Texas.

TABLE I

SUMMARY OF SEVENTY-SEVEN CASES

	No	Reactions 1°	2°	3°	Previous Laparotomy	Syphilis	Clinical Group I	II	III	IV
White	9	11	12	3	13	5	4	13	9	9
Colored	24	9	6	3	7	14	3	7	10	22
Totals	33	20	18	6	20	19	7	20	19	31

with or without bismuth was often prescribed if diarrhea became excessive. We now omit bismuth entirely during treatment because of the possible enhancing effect the secondary beta radiation from the bismuth may have on the intestinal reaction.

Second degree reactions are those in which ulceration with many bleeding points is seen, plus hyperemia and bullous edema. Rectal pain is a fairly common subjective symptom in this group. A bearing-down pain is often described late in the course of the reaction, indicating fibrosis. The ulceration may be in the form of fairly typical punched-out single round ulcer or in irregular single or multiple ulcers of a "beefy" red appearance. Temporary stricture (Fig. 1), usually of short duration, may occur in this group. The late reactions will usually be accompanied by bleeding either in small or large old clots to fresh gross hemorrhage. This gives the appearance of "factitial proctitis" described by Buie and Malmgren.[5] This reaction occurred in 24 of 77 cases in this series in which bowel reactions were described and in which six months had elapsed since treatment. Cathie[6] reported ulceration as high up as the duodenum which was well removed from field of irradiation, although consideration of such intestinal complication is outside the scope of this paper and was not encountered in any of our cases. The treatment for the second degree reaction consisted of starch or warm saline enemas after bowel movements, followed by instillation of 4 to 6 ounces of warm olive oil to be retained as long as possible.

Third degree reactions are those which progress to fibrosis of one or more of the intestinal coats with or without extrinsic fibrosis. Whatever degree of fibrous stricture results, it will be permanent, except for the dilatation which may be accomplished by the fecal stream or artificially by bougie. Extreme fibrosis of the posterior half of the pelvis is encountered in a fair percentage of treated cases. It is in those cases not showing extrinsic fibrosis of the sigmoid in which resection may be considered. The cases reported by Todd[1] were divided into extrinsic and intrinsic reactions, and successful resection of the stricture of the sigmoid with end-to-end anastomosis was accomplished in several cases of the intrinsic variety. This procedure appears feasible in one case under observa-

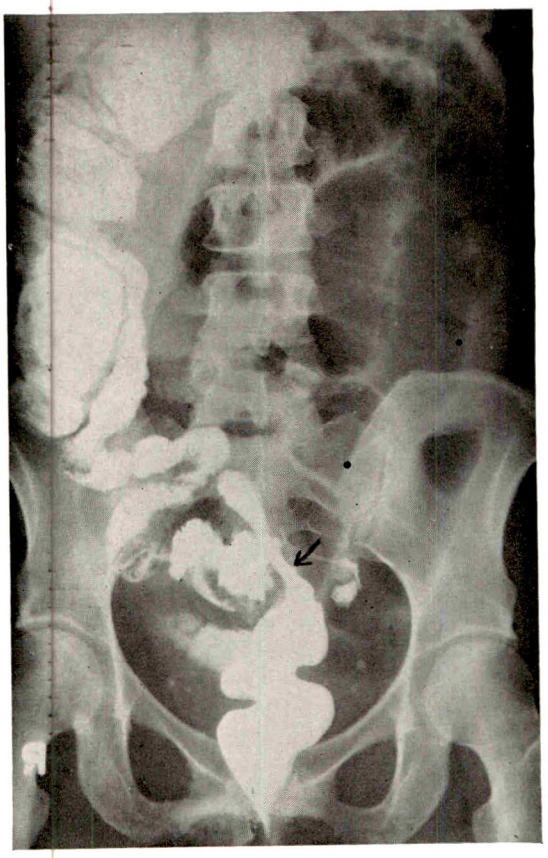


FIG. 2. Case 77. Colored, aged forty-three, para II, clinical Group IVa. Squamous cell carcinoma cervix Grade 3. Bilateral salpingectomy and oophorectomy, 1928. Ileosigmoidal fistula at arrow. Previously administered bismuth is seen in cecum and ascending colon. Anteroposterior caliper 20 cm. External roentgen therapy 8,150 r, four portals October 1, 1940 to November 4, 1940. Intravaginal cone, 4 cm. portal, 5,148 r between October 15, 1940 and October 29, 1940. Intra-uterine and vaginal radium, 6 sources, 4,686 mg-hr. November 30, 1940 to December 7, 1940. Diarrhea but no blood third week. Controlled. Obstructive symptoms during January, 1941. Laparotomy January 30, 1941. Death February 5, 1941. No autopsy. No evidence of neoplasm in biopsy specimen from site of fistula (Fig. 3).

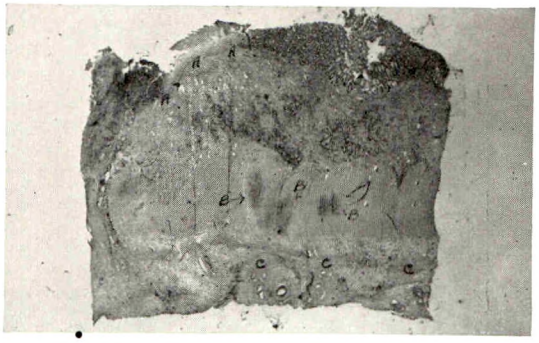


Fig. 3. Case 77. Photomicrograph (×10). Specimen taken from sigmoid at site of ileosigmoidal fistula. *A*, border of infarcted area which is ulcerating; *B*, early infarction of muscular layers; *C*, thickened fibrous subserosa. No evidence of neoplasm.

tion here at the present time. Devine's colostomy was performed March 5, 1941, and at preliminary exploration it was found that the sigmoid was fairly mobile. Resection will probably be carried out later.

Small bowel obstruction was not encountered in any of the cases in this series. The patient in whom ileosigmoidal fistula (Fig. 2) developed had extensive localized injury of the ileum at the site of the fistula. Figure 3 shows the microscopic evidence of necrosis in such an area. It has been stated that previous laparotomy may predispose to small bowel injury with later obstruction.[2] This is certainly plausible but did not have significant relationship in our series. Twenty patients in the entire series had laparotomy prior to the institution of treatment and they were divided among the four reaction groups as shown in Table II.

Sigmoidal stricture necessitating colostomy occurred 5 times in 100 consecutive cases receiving roentgen and radium treatment for cancer of the cervix between the early part of 1937 and October, 1940. It is unlikely that more of these cases will eventually require operative treatment for obstruction, since the majority of such lesions occur between six and eight months

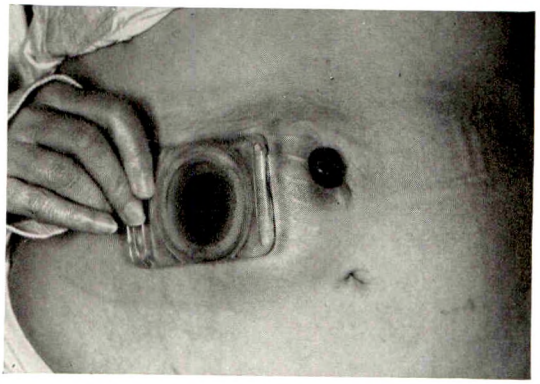


Fig. 4. Case 29. Non-irritating plastic device used over proximal loop of colostomy. Short tight plug inserts into bowel opening with surrounding collar which prevents leakage. This shows usual site of Devine colostomy.

following completion of treatment.[1] However, obstruction has been reported[2] as occurring as long as eight years after treatment. This question concerning our series of cases will be answered definitely at some future time inasmuch as we are maintaining a close follow-up on each patient.

Colostomy for severe proctitis was necessary in one instance, and since operation

Table II

SEVENTY-SEVEN CASES

	No Reaction		1st Degree		2nd Degree		3rd Degree		Total
	W	C	W	C	W	C	W	C	
Total reactions	9	24	11	9	12	6	3	3	77
Previous laparotomy	4	4	4	1	4	0	1	2	20
Syphilis	2	7	1	4	0	2	2	1	19
Clinical Group I	2	1	0	0	0	2	2	0	7
Clinical Group II	2	4	4	3	7	0	0	0	20
Clinical Group III	2	6	3	4	3	0	1	0	19
Clinical Group IV	3	13	4	2	2	4	0	3	31

W—White
C—Colored

the proctitis has resulted in about 50 per cent narrowing at the rectosigmoid. If there is no increase in the stricture during the next 6 months, the colostomy will be closed as it is known that the fecal stream will enlarge the lumen to some extent and accommodate itself to some degree of narrowing. This patient (V. F., Case 44, Table III) had clinical Group 3 carcinoma of the cervix, for which treatment was completed in August, 1939. The patient had diarrhea beginning shortly after with remissions and exacerbations until colostomy in April, 1940. She had a second degree reaction which produced bleeding only occasionally. She has had short periods of diarrhea from the colostomy, usually following dietary indiscretion. The patient is otherwise in good health.

TREATMENT TECHNIQUE

The general plan of treatment included an external series of high voltage roentgen irradiation to the pelvis followed immediately by intracervical, uterine and intravaginal radium applications. Roentgen therapy was delivered by a 200 kv. (peak) constant potential apparatus operated at 18 ma. of current and 52 cm. focal skin distance. The filters used varied from 0.75 mm. copper to medium Thoraeus. The half-value layers for 0.5 mm. and 2 mm. copper for the above factors are 1.18 mm. and 2.12 mm. copper respectively. Radiation was delivered through the usual two anterior and two posterior portals; in obese women two lateral portals were added. The portals were 15 by 15 cm. in size for the first 62 cases and 10 by 15 cm. for the remainder. The beam was tilted about 10 degrees toward the midline. Treatment was given daily except Sunday and the daily dose varied from 200 r to one portal to 250 r to each of two portals. Most cases are started now on 100 r to each of two portals and after completion of one pelvic cycle, increased to 150 r to each portal, and thus increasing at the rate of 50 r per portal per cycle until a maximum of 250 r per portal is reached. All measurements were made with a Victoreen condenser type r-meter, which was recalibrated by the manufacturer every six months and checked with other instruments. The intensity for all techniques used was measured in air. Alternate portals were treated on successive days so that each portal received the same total dose. The latter varied with the anteroposterior caliper measurement and an effort was made to deliver 5 to 6 threshold erythema doses to each adnexal region. The largest total dose to an external portal was 3,000 r when four portals were used and 2,000 r when six portals of entry were used. The external series was completed in twenty-five to thirty-five days. There was no significant permanent damage to the skin in any case. Some induration resulted in a few cases, such as is seen in Figure 7.

Since January, 1940, we have added intravaginal roentgen irradiation through an Odmann cone whenever the lesion was primarily of an exophytic type and small enough to be completely included in the field of irradiation and if the configuration of the vagina adapted itself to easy insertion of the cone. Only two cone sizes, 3 cm. and 4 cm. in diameter, were used. The physical factors for this irradiation were 200 kv. (peak), 18 ma., 45 cm. distance and 0.25 mm. copper and 0.5 mm. aluminum external filtration. The inherent filtration of the tube is equal to 0.25 mm. copper. For the first few cases 200 kv. (peak) and 0.5 mm. copper were used, but it was felt that the doses delivered to the rectum and sigmoid were too great. The daily dose was usually 450 r until a total of 5,000 r was administered. This radiation was given concurrently with the external series.

Multiple source radium technique was used in every instance. The cervix was dilated under anesthesia and four-chambered tandem silver capsule, with a wall thickness of 1.6 mm., was inserted into the uterus and cervical canal. Each of the two distal chambers resting in the fundus contained 19.8 mg. (6–3.3 mg. cells), and each of the two proximal chambers in the cervical canal contained 26.4 mg. (8–3.3 mg. cells).

TABLE III

DOSAGES AND REACTIONS

Case No.	Roentgen Rays (r)	Radium (mg-hr.)	Reaction	Case No.	Roentgen Rays (r)	Radium (mg-hr.)	Reaction	Case No.	Roentgen Rays (r)	Radium (mg-hr.)	Reaction
1	Outside	4,710	No	33	11,489	5,333	1	60	13,294*	5,064	2
2	Outside	2,640	1	34	18,110*	5,333	1	61	15,907*	4,560	2
3	10,584	5,575	No		5,040†				4,950†		
4	11,842*	4,147	No	35	12,152	5,630	No	62	12,112*	0	No
5	4,848	5,376	1	36	11,730	4,156	No		4,824†		
6	8,073	5,010	No	37	7,452	0	No	63	8,600	0	No
7	6,403	5,456	No	38	12,524	5,332	No	64	8,656	4,422	2
8	2,598	7,200	No	39	13,671	5,659	2	65	8,224	2,000	1
9	4,000	4,300	No	40	16,692*	5,604	2		5,040†	Stump	
10	18,403*	0	No	41	9,996	2,956	1	66	8,100	0	No
11	12,400	4,960	No	42	11,084	5,392	2		5,040†		
12	8,280	4,920	No	43	12,274	5,392	1	67	3,850	6,013	2
13	9,418	2,602	No	44	10,846	5,659	2	68	18,490*	2,901	1
		Stump		45	14,948	4,175	1		5,040†		
14	10,580	0	No	46	9,894	5,392	2	69	9,500	4,612	1
15	9,744	4,977	No	47	12,274	5,431	3	70	9,600	4,920	No
16	17,696*	4,620	No	48	12,240	5,659	2		5,616†		
17	7,590	0	No	49	9,622	4,435	2	71	7,950	0	2
18	9,564	4,777	1	50	12,750*	5,333	1		5,040†		
19	6,490	3,811	No	51	10,064	4,643	2	72	9,450	5,070	2
20	8,058	4,826	No	52	7,956	3,925	No		5,040†		
21	11,289	4,901	1	53	10,024	5,943	No	73	8,000	4,884	2
22	5,261	3,600	No	54	7,565	5,091	2		5,040†		
23	11,942	5,405	2		4,813†			74	8,100	4,771	3
24	16,648*	5,618	1	55	8,228	4,620	2		5,040†		
25	9,267	4,663	No		5,000†			75	6,120	3,564	1
26	8,036	5,128	No	56	8,704	0	1	76	8,000	2,338	1
27	8,269	3,947	1	57	11,224*	4,310	3		3,600†		
28	8,250	5,181	No		5,250†			77	8,150	4,686	3
29	11,481	5,808	3	58	9,464	0	No		5,148†		
30	12,230	3,059	No		1,040†						
31	11,700	5,333	1	59	8,160	4,158	1				
32	20,016*	4,887	3		5,000†						

* Two external series.
† Intravaginal cone.

Each cell is 1 cm. in length and has a wall thickness of 0.2 mm. platinum, providing in addition to the capsule a total filtration equivalent to 1 mm. platinum. The capsule was placed in a rubber sac 2 mm. in thickness. The dose thus given was approximately 3,000 mg-hr. In the last 8 cases a capsule of 2.6 mm. silver wall thickness was used. Hereafter a silver capsule providing total filtration equivalent to 0.5 mm. of platinum will be used.

Within a few days after removal of the intra-uterine applicator a London or Kaplan colpostat or single rubber cylinder was introduced into the vaginal fornices. In many cases the vagina was so contracted that the cylinders rested against the cervix. The filtration was the same as for the intra-uterine application except that the rubber cylinders have a wall thickness of 1 cm. The vagina was packed tightly with gauze in order to hold the applicators in position and maintain as much distance between the bladder and rectal walls and the radium sources as possible. The gauze was well moistened with olive oil to reduce irrita-

tion of gauze to vaginal mucosa. The vaginal dose was approximately 1,000 mg-hr. per capsule. Occasionally three capsules were used; usually only two.

Thirteen cases received a second series of deep roentgen therapy because of persistence or recurrence of the lesion. The factors used were similar to those for the first series except that only 1,000 to 1,200 r per portal was administered. Table III shows the reaction in these cases.

When the intravaginal cone therapy was added a few cases were treated with only roentgen irradiation. One case developed a recurrence in the left vaginal fornix about two months after completion of therapy. This was controlled satisfactorily by the use of radium, although it was decided that radium should be used in the vaginal fornices to supplement the cone therapy in every case. The regular intra-uterine radium application was used in every case receiving cone therapy. Hereafter the intracervical portion of the application will be omitted. If the uterus is fairly large, two or three capsules will be inserted into the fundus to supplement the cone therapy and the vaginal radium.

Distribution of radium sources within uterus and vagina is important. Multiple sources within the uterus will displace each other to the lateral aspects of the uterus and thus deliver higher doses to the broad ligaments. Careful positioning and packing of vaginal applicators are important in order to prevent displacement of applicator downward against the rectum or forward against the bladder. An applicator becoming dislodged from the vaginal fornix and coming to lie on the posterior wall of the vagina may produce a very severe factitial proctitis, while the same dose in its proper place would have produced little or no reaction.

COMMENT

In the tabulations of reactions (Table I) 23 cases were omitted because of death less than six months following completion of treatment or because only a small amount of palliative treatment was given. None of these, however, died with intractable diarrhea. Some of them, however, had first degree reactions, but none had second degree reactions. Seven of the 23 cases died from one to five months after completion of treatment and no statements concerning bowel reactions were recorded. If any one of them had a second or third degree reaction we would, in all probability, have known it. In determining the percentage of reactions, if these are included as "no reaction" cases, then the percentage having reactions becomes 50 per cent. Fourteen were given only palliative treatment or died of other cause before treatment was complete. We were unable to trace 2 cases. A few of the first degree reaction cases were not asked whether they had passed blood although the data concerning the diarrhea was recorded. These possible sources of error hold only for the first year cases. Thirty-nine per cent of the entire group is well and free of clinical evidence of active disease. A few of the "no reaction" cases listed in Table III received more treatment than certain of those who developed third degree reactions, but appear entirely normal on pelvic examination at the present time. This points strongly to a marked variation of tissue susceptibility in different individuals.

CASE REPORTS

Intrinsic Reaction with Colostomy.

CASE 29 (Table III). E. I., white, aged forty-four, para 1, was admitted October 4, 1938, complaining of intermenstrual bleeding for one year. General physical examination was negative except for numerous dental caries and pyorrhea. Inspection of the cervix revealed a small erosion on the anterior and left aspects without extension to the vaginal wall. On bimanual examination the uterus was freely movable and normal in size without suggestion of involvement in either adnexal region. Classification of clinical Group 1 was made. Pathologic diagnosis: transitional cell carcinoma Grade 3. Red blood cell count was 4,100,000; hemoglobin 85 per cent and negative Kline reaction. Urine within normal limits. Bilateral

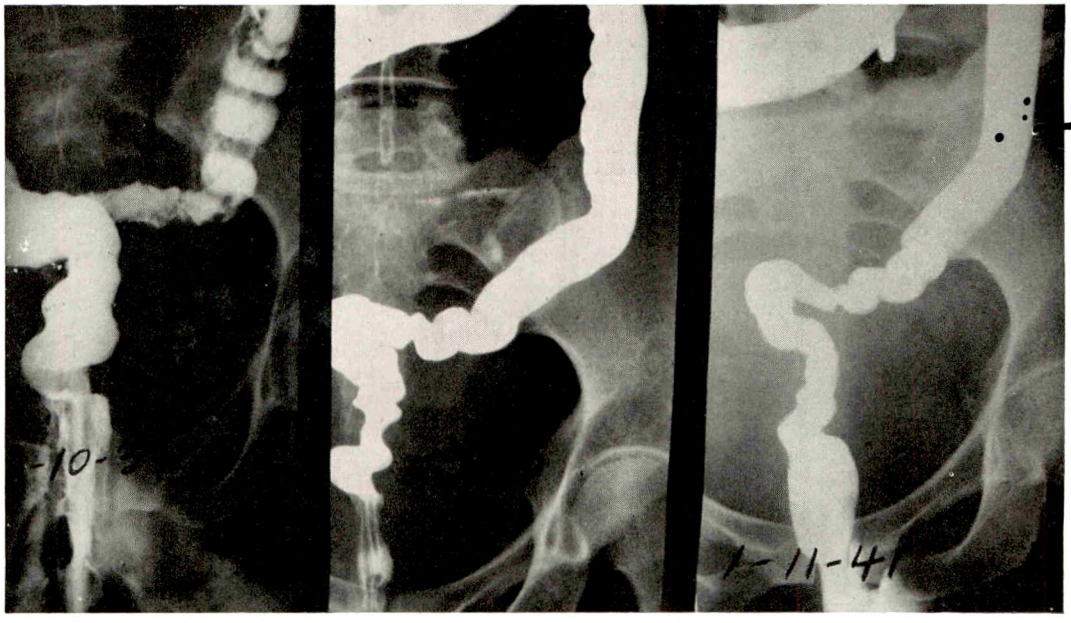


Fig. 5. Case 29. Factitial sigmoiditis and condition seventeen months after colostomy.

pyeloureterograms failed to show deviation from the normal.

Roentgen therapy directed through six 15 by 15 cm. pelvic fields was begun on October 4, 1938, and completed on November 17, 1938. Physical factors were: 200 kv. (peak) constant potential, 18 ma., 52 cm., focal skin distance, 1 mm. copper and 0.5 mm. aluminum filtration; 156 r, measured in air, was given through each of two portals every day for a period of thirty-seven days for a total of 11,481 r. The antero-posterior measurement just above the symphysis pubis was 18 cm. Radium was administered between November 17, 1938 and November 23, 1938: 2,957 mg-hr. in the uterus and cervix and 2,851 mg-hr. in the vagina, making a total of 5,808 mg-hr. Filtration 1 mm. platinum equivalent.

Patient had no significant complaints until July, 1939, about seven and a half months after completion of radiation therapy, when she began having three to four loose stools daily, mixed with blood and mucus, and accompanied by considerable persistent tenesmus. Upon examination, the cervix was in good condition but bound down posteriorly. The adnexa were negative except for moderate induration.

Roentgenoscopic examination of the colon, with barium enema, demonstrated considerable spasm of the rectum, irregular narrowing of the proximal third of the sigmoid and adherence of sigmoid loops to each other. Proctoscopic examination demonstrated typical second degree reaction of both the rectum and sigmoid.

The patient was admitted to the hospital July 9, 1939, and an attempt was made to control the bloody diarrhea by frequent starch and saline enemas followed by instillation of warm olive oil. The patient was losing weight and a colostomy was decided upon. A Devine colostomy of the transverse colon was done on August 23, 1939. Postoperative recovery was rapid and the patient left the hospital on September 15, 1939, in excellent condition except for slight diarrhea from the proximal colostomy. opening. There have been no urinary complaints at any time.

Since operation the patient has gained 13 pounds in weight, no complaints except for occasional slight diarrhea from the colostomy. Repeated pelvic examinations have shown no evidence of neoplasm. Proctoscopic examination on three or four occasions during the past year have shown slight persistent narrowing of the proximal sigmoid, as shown in Figure 5. This case is now ready for closure of colostomy.

Marked Extrinsic Reaction with Development of Intrinsic Reaction Eight Months after Colostomy.

Case 47 (Table III). A. D., white, aged thirty-four, was admitted July 24, 1939, com-

plaining of intermenstrual bleeding for the past eight or nine months. Thick yellow vaginal discharge several years. Seven pounds weight loss past two months. Patient was in good general condition except for positive Wassermann reaction, for which she had had some treatment. Cervix showed small early lesion of the anterior lip, which bled easily. She was classified as clinical Group 1. Biopsy proved presence of adenocarcinoma Grade 3. Bilateral retrograde pyelograms were within normal limits except for biliary calculi right upper quadrant.

Roentgen treatment was started July 31, 1939, delivering 170 r to two portals daily, using the six portal technique. The antero-posterior measurement just above symphysis pubis was 20 cm. Treatment completed September 18, 1939, for a total dose of 12,274 r. Intra-uterine and cervical radium in tandem was applied August 23, 1939, administering 3,000 mg-hr. through 1 mm. platinum filter. One week later 650 mg-hr. was applied in each lateral vaginal fornix and 600 mg-hr. a few days later in the same areas. One month later patient had gallstone colic, followed by jaundice and light colored stools. Cholecystectomy was performed November 10, 1939, with an uneventful convalescence.

Patient first noticed constipation early in November, 1939, and when seen December 1, 1939, had not had any bowel movement for several days despite enemas and mild laxatives. There was occasional vomiting but no diarrhea. Examination revealed a soft non-distended abdomen, although flat film of abdomen (Fig. 6) demonstrated tremendous distention of entire colon proximal to sigmoid, and barium enema outlined irregular narrowing of rectum. The cervix at this time showed marked irradiation reaction and the upper vagina was contracted and very tender. Cervix could not be dilated by gentle pressure by means of small probe. The

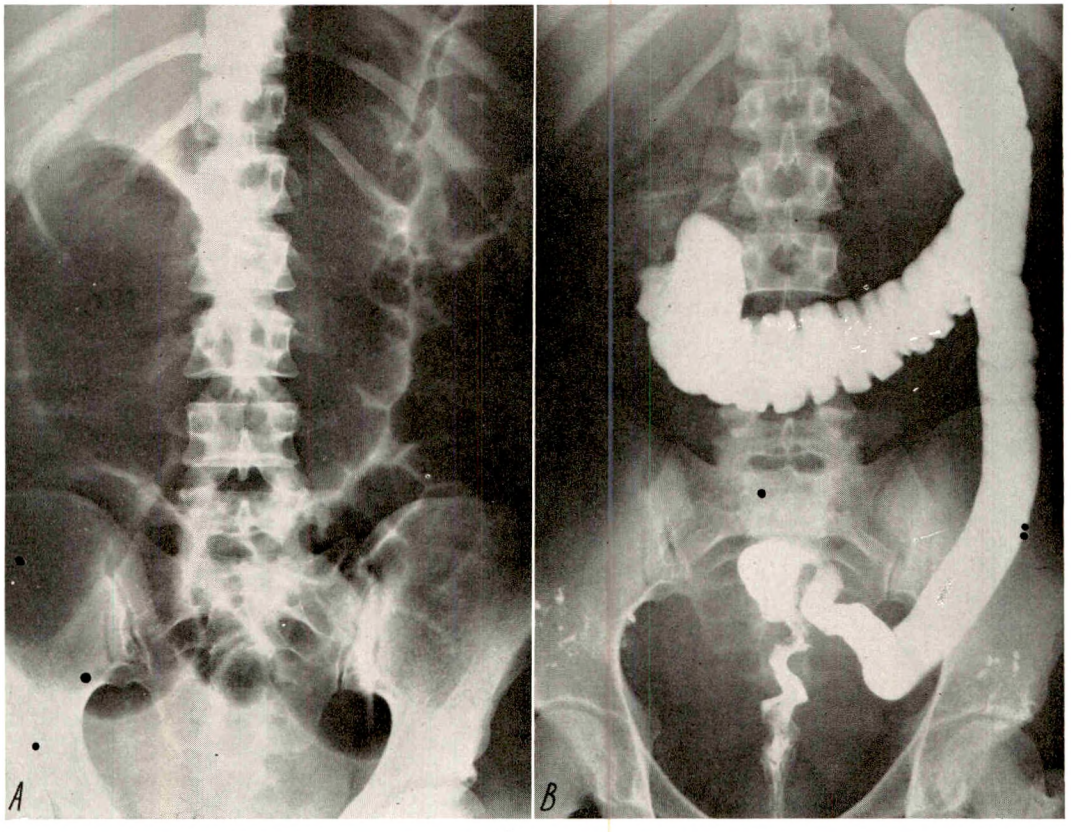


FIG. 6. Case 47. *A*, marked colonic distention proximal to irradiation stricture of distal sigmoid and rectum. Colostomy December 14, 1939. *B*, barium-filled colon, February 25, 1941, showing stricture of rectum secondary to extrinsic irradiation reaction.

uterus and pelvis were found firmly fixed on rectal examination with diffuse fibrosis throughout posterior half of pelvis.

On December 14, 1939 a Devine colostomy of the transverse colon was performed. Postoperative course was very satisfactory. General condition immediately improved.

The patient noticed swelling of both lower extremities a few months later, slightly more of the left side. There was considerable induration of the skin in both inguinal regions externally and rather marked lymphedema of both lower extremities. There was also marked swelling of the labia (Fig. 7).

Patient continued to improve and her general

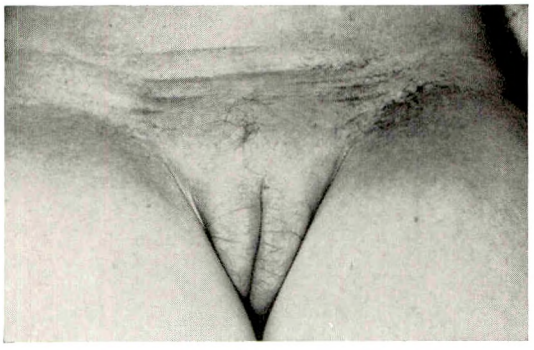


Fig. 7. Case 47. Induration of inguinal regions and lymphedema of labia majora eighteen months after treatment in a case of extrinsic irradiation reaction of rectum.

condition became very satisfactory. She was admitted to the hospital, however, in August and again in November, 1940, for hemorrhage per rectum. Hemorrhage completely controlled on bed rest and transfusions on both occasions. Monsel's solution was also administered per rectum as retention enema. There has been no bleeding since except for a few clots on February 18, 1941.

Mucosa of rectum was negative by proctoscopy. Palpation per rectum gave the impression that the rectum was tunneled through a hard fibroid molded into the posterior portion of the pelvis. This same condition is still present and demonstrated on barium enema film made February 25, 1941 (Fig. 6). Bilateral retrograde pyelograms on December 4, 1940, were negative except for slight clubbing of minor calyces. Patient last seen on February 25, 1941, when there were no complaints except for some swelling of the lower extremities below the knees. Normal weight and strength. Red blood cell count 3,500,000; hemoglobin 70 per cent, white cell count 4,500. Patient has had regular antisyphilitic treatment since first observation in July, 1939.

Colostomy for Severe Proctitis.

Case 44 (Table III). V. F., white, aged thirty-five, para III, admitted June 29, 1939; no previous operations or serious illness. Complaints were intermenstrual discharge six months, increase in duration of menses to ten to sixteen days for the past three months, pain in left lower quadrant one month, and 12 pounds weight loss during past six months. Physical examination was negative except for a small ulcer on anterior aspect of anus and a few external hemorrhoids. Inspection of cervix showed it completely covered by an exophytic growth without visible extension to vaginal wall. Adnexa indurated with some fixation of uterus. Clinical Group III carcinoma of the cervix. Pathologic diagnosis: squamous cell carcinoma Grade 3. Kline test negative, red blood cell count 3,300,000, hemoglobin 64 per cent, pyeloureterograms normal.

Roentgen therapy was given for twenty-seven days between June 29 and August 22, 1939, through six pelvic portals. The anteroposterior measurement just above symphysis pubis was 16 cm. Physical factors were: 200 kv. (peak) constant potential, 18 ma., 52 cm. focal skin distance, filtration 1 mm. copper plus 1 mm. aluminum; 204 r, measured in air, was given through each of two 15 by 15 cm. portals daily with exception of a few interruptions. On August 28, 1939, radium was introduced in tandem into the cervix and uterus for a dosage of 2,956.8 mg-hr. using 1.6 mm. silver and 0.2 mm. platinum filtration in 2 mm. rubber tube; followed by 2,702 mg-hr. in vagina (3 sources), same filtration in 5 mm. hard rubber London type cylinder during next five days.

Two days after completion of radium treatment, the patient began to have diarrhea, pain with defecation and blood in stools. These symptoms continued until hemorrhoidectomy on October 4, 1939. The patient was then free of bowel symptoms until January, 1940, when she noticed straining at stool and blood on outside of stool. Stools were formed and ribbon-like but frequent.

Proctoscopy on April 1, 1940, showed rectal mucosa "beefy" red with bleeding points and a slight stricture 8 cm. from anus. Symptoms became progressively worse, and on April 17,

1940, a Devine colostomy was performed. Patient was discharged on twelfth postoperative day in excellent condition. There has been no bleeding from rectum since. Last seen in February, 1941, when she had no complaints except for diarrhea from colostomy when she tried foods not on her usual diet list. The lesion of the cervix had completely disappeared and no masses were felt in pelvis. Adnexa fairly pliable. A slight stricture was felt at the tip of the examining finger in the rectum. Proctoscopy showed rectal mucosa smooth and normal in color; the lumen at the stricture appeared to be about 2 cm. in diameter. Barium enema studies, however, failed to show any evidence of abnormality. Check-up bilateral pyeloureterograms made March 20, 1940, were again normal. It is intended to close the colostomy after a few months have elapsed.

Comment. Even if this patient should develop obstruction again at some future time after closure of colostomy, re-establishment of the colostomy is a relatively simple procedure with little risk to the patient.

Extrinsic and Intrinsic Reactions with Autopsy Findings.

Case 57 (Table III). M. R., colored, aged fifty, was admitted January 12, 1940, with complaint of profuse vaginal bleeding of twenty-four hours' duration. Patient was not beyond the menopause and had passed small amounts of blood and clots irregularly for several years. Patient was taking "shots" in the arm in the Venereal Disease Clinic.

General examination was essentially negative, except for moderate anemia and positive Wassermann and Kline reactions. Red blood cell count 3,140,000, with a hemoglobin of 62 per cent. The cervix was irregular and nodular and bled freely on manipulation. Uterus was enlarged and somewhat fixed. The fundus gave the impression of a smooth round mass of a hard woody consistency to the examiner. She was placed in clinical Group IVa and so classified in our tables. Pathologic diagnosis: squamous cell carcinoma Grade 3. It was found that the patient had been given adequate antisyphilitic treatment in the Venereal Disease Clinic from July, 1938, to June, 1940, and her spinal fluid Wassermann test was negative but her blood was Wassermann fast.



Fig. 8. Case 57. Bilateral retrograde pyeloureterograms showing considerable hydronephrosis and hydroureter six months after treatment. Similar studies were normal at time of treatment. At autopsy only fibrosis was found obstructing the ureters.

Roentgen therapy was started on the day of admission and it was decided to use four external portals and the intravaginal cone for irradiating the cervix directly. The anteroposterior measurement just above the symphysis pubis was 17 cm. For the external irradiation 1 mm. copper and 0.5 mm. aluminum filtration was used and a dose of 170 r was administered through each of two 15 by 15 cm. portals daily, except Sunday. The external series was completed on February 9, 1940, and a total of 8,024 r had been given through four portals. The physical factors for intravaginal therapy, which was administered from January 12, 1940, to January 29, 1940, at the rate of 350 r per day for a total of 5,250 r, were 200 kv. (peak), 18 ma., 45 cm. distance, 0.5 mm. copper and 0.5 mm. aluminum filtration. The cone used was 4 cm. in diameter. Radium therapy on February 15, 1940, consisted of introduction of the four-chambered silver capsule (1 mm. platinum equivalent) into the uterus. Each of

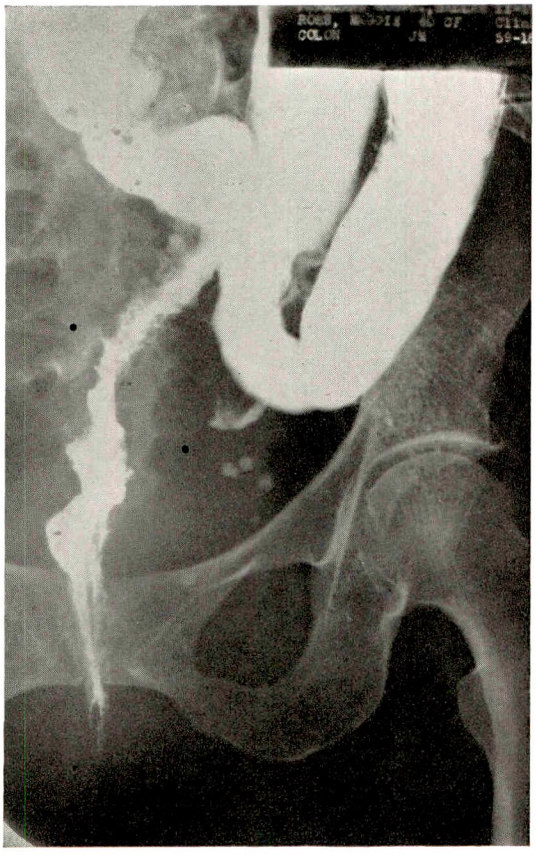


Fig. 9. Case 57. Barium filling of colon showing marked irregular narrowing of rectum prior to colostomy.

the two chambers high in the uterus contained 23.1 mg. and each of the two within the cervix contained 29.7 mg. This was left in place approximately twenty-nine and one-half hours and the dose calculated to be 3,106.8 mg-hr. On February 19, 1940, a single London type hard rubber capsule was placed against the cervix and 1,202.8 mg-hr. administered. Total radium dose therefore was 4,309.6 mg-hr.

Bilateral pyeloureterograms made January 31, 1940, were not abnormal. Similar studies July 31, 1940, demonstrated fairly marked dilatation of the left ureter and kidney pelvis (Fig. 8). Subjectively the patient enjoyed entirely satisfactory health, going about her usual work, during the six months following completion of irradiation. Patient began, however, to feel weak and complained of pain in the anterior aspect of the left thigh in July, 1940. The cervix at this time was completely replaced by grayish necrotic crater with some bleeding from the margins on distention of the vagina. A biopsy from the border of the crater demonstrated necrosis with subacute inflammation and fibrosis. By rectal examination there was complete fixation of all structures, particularly on the left side. The rectum itself was negative to palpation. On the day following the pyelography on July 31, 1940 (Fig. 8), the patient had chills and fever and remained in bed for one week. She stated she had suffered considerable pain in the region of the left costovertebral angle, which was still present and for which ureteral dilatation provided relief.

Because of the hydronephrosis which had developed since preliminary treatment, it was decided that another pelvic series should be given and this was commenced on July 23, 1940, and discontinued August 1, 1940, because of weakened condition of patient. Patient next seen October 1, 1940, when she had no complaints except that she stated she had had vaginal bleeding for one hour two days before and loss of strength. The vagina at this time was funnel shaped, the cervix completely destroyed and marked "epithélite" formation. The rectum itself was still negative. There was marked fixation and induration throughout left broad ligament.

The bowel symptoms began early in November, 1940, with bloody loose stools and pain in the lower abdomen. The passing of blood clots per rectum continued and on November 15, 1940 examination of the colon with the aid of barium enema (Fig. 9) demonstrated extensive irregular narrowing of the entire rectum and distal sigmoid. Patient continued to pass blood

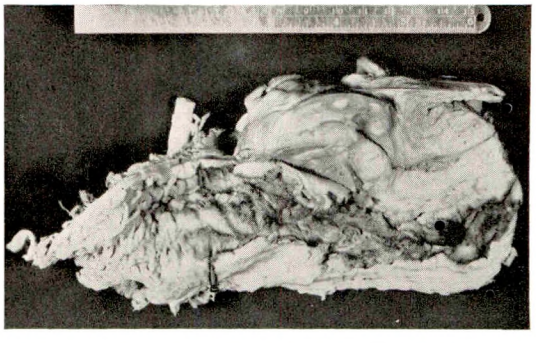


Fig. 10. Case 57. Photograph of gross autopsy specimen including rectum, portion of sigmoid, vagina, uterus and bladder at top. Marked third degree irradiation reaction of rectum.

clots from rectum and was hospitalized on December 6, 1940. Conservative local treatment was carried out without noticeable change. Devine's colostomy of the transverse colon was performed on December 18, 1940. Patient began to have elevation of temperature, of a septic type, on the day of the operation and this gradually rose until death on December 24, 1940.

At autopsy the entire peritoneal cavity was filled with purulent material which flowed freely from the incision. Both kidneys showed hydropyonephrosis. The sigmoid colon was seen to enter a hard mass (Fig. 10) within the pelvis which was found to contain rectum, vagina, uterus, bladder and surrounding tissues. It appeared that at least 30 cm. of the sigmoid colon and rectum had undergone necrosis and contained foul smelling, grayish-yellow material. In one area the serosa of the sigmoid had formed a large pocket containing this necrotic material. There was extensive fibrosis of the wall of the rectum, most marked at the level of the cervix. Sections from numerous blocks of tissue from all representative areas, including the lower ends of the ureters, failed to show any evidence of carcinoma. The photomicrograph shown in Figure 11 was taken from the wall of the distal sigmoid. The mucosa was eroded and ulcerated in multiple areas. It showed many infiltrating neutrocytes, lymphoid and plasma cells. Subserosa was markedly thickened and proliferation of intimal layers of blood vessels with narrowing of lumena was seen. No neoplastic cells present.

Comment. There was no palpable evidence of extension into the paracervical tissues at beginning of treatment. Urological studies at that time failed to show deviation from the normal. The cervical lesion was brought well under control but the ureters gradually dilated until finally hydronephrosis supervened. This suggests that the fibrosis found surrounding the ureters and elsewhere within the pelvis at autopsy resulted from the treatment.

It has been our experience that patients with syphilis, particularly if inadequately treated, do not respond to radiation treatment of carcinoma of the cervix as well as those without syphilis.

SUMMARY AND CONCLUSIONS

1. An individual variation in susceptibility exists in the ability of different patients to tolerate radiation treatment.

2. Detailed dosages and reactions are tabulated in 77 cases receiving roentgen and radium treatment for cervical cancer. Some of the "no reaction" cases received more treatment than certain of those suffering third degree reactions.

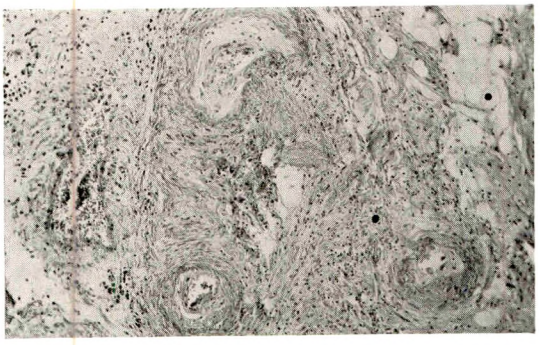


FIG. 11. Case 57. Photomicrograph showing intimal proliferation, with adjacent fibrosis, representing irradiation effect in wall of rectum. No evidence of carcinoma.

3. Even by staying well within limits of accepted dosage, reactions may occur several months or years later, without any immediate reaction after treatment. The symptoms of these late reactions may be mistaken for hopeless recurrence by other physicians.

4. Radiation therapy of cancer of the cervix sufficient to eradicate the disease will produce clinical evidence of large bowel reaction in a high percentage of cases. Fifty-seven per cent in this series had bowel reaction varying from slight diarrhea to stricture formation.

5. Reaction severe enough to demand colostomy occurred in 6 cases, or 7.9 per cent of 77 cases.

6. Post-irradiation stricture of the distal large bowel, unlike ureteral stricture, is often temporary and always amenable to surgical treatment, except for the rare complication of fatal hemorrhage from the rec-

tum after colostomy. This did not occur in our series.

7. Intractable diarrhea associated with second degree irradiation reaction of rectum or sigmoid will also yield to colostomy. The bowel should be put to rest by use of the Devine type of colostomy before the patient becomes emaciated, and the colostomy may be closed when the lesion is well healed. Twelve to eighteen months will suffice.

8. There are two types of rectal and sigmoidal late reactions—extrinsic and intrinsic.

9. Both types of involvement show vascular occlusion as their chief histologic feature, followed by infarction in the wall and mucosal ulceration and later fibrosis unless healing occurs before reaction becomes advanced. Strictures form from organization of submucosal granulation tissue. There may be a combination of both reactions.

10. Description of an autopsy is included in which evidence suggests that fibrosis sufficient to obstruct the ureters may occur as a result of radiation treatment.

11. In patients suffering second and third degree reaction, occasional bleeding from rectum may never entirely disappear.

1101 Medical Arts Building
Houston, Texas

REFERENCES

1. Todd, T. F. Rectal ulceration following irradiation treatment of carcinoma of the cervix uteri. *Surg., Gynec. & Obst.*, 1938, *67*, 617–631.
2. Jones, T. E., Benign stricture of the intestine due to irradiation. *Surg. Clin. North America*, 1939, *19*, 1185–1194.
3. White, W. C. Acute intestinal obstruction following radium treatment of cervix uteri. *Ann. Surg.*, 1937, *105*, 292–295.
4. Corscaden, J. A., Kasabach, H. H., and Lenz, M. Intestinal injuries after radium and roentgen treatment of carcinoma of the cervix. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 871–894.
5. Buie, L. A., and Malmgren, G. E. Factitial proctitis; justifiable lesion observed in patients following iradiation. *Internat. Clin.*, 1930, *3*, 68–77.
6. Cathie, I. A. B. Ulceration of the small intestine following irradiation of the pelvis. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 895–898.

Vol. 49 No. 3

THE EFFECT OF ROENTGEN RAYS UPON THE GROWING LONG BONES OF ALBINO RATS

II. HISTOPATHOLOGICAL CHANGES INVOLVING ENDOCHONDRAL GROWTH CENTERS*

By CHARLES L. HINKEL, M.D., MED. SC.D.

Walter Reed General Hospital

WASHINGTON, D. C.

HISTORICAL

SINCE the time of Perthes[34] (1903), who first demonstrated gross underdevelopment of osseous structures following roentgen irradiation, many investigations have been carried out in this field. The first microscopic study of irradiated bones was reported by Recamier and Tribondeau.[36] They concluded that roentgen rays caused stunting of growth but that no histological changes were demonstrable. Salvetti[38] (1914), studying roentgen-ray effects upon fracture healing, stated that "microscopic changes were not sharp." Segale[39] (1920) first described definite microscopic changes in the bones of young rats after doses of 7 to 20 Holzknecht units of roentgen rays The changes consisted largely of disarrangement of cartilage cells and were most marked after third degree skin burns. The author considered them permanent, with no tendency toward reparation. Hoffman,[25] three years later, showed the same disturbed microscopic picture in growing epiphyses following amounts of roentgen rays exceeding one erythema dose. He also noted decalcification of the irradiated bones. Descriptions of gamma- and roentgen-ray effects upon adult and adolescent diaphyseal bone were supplied by Phemister[35] and Ewing[20] (1926). The former described decalcification and necrosis, while the latter showed the dense sclerosis of "radiation osteitis."

Brooks and Hillstrom[4] (1933) described characteristic microscopic changes of column disorganization and retarded growth after only 40 per cent of an erythema dose in young rabbits. Dahl[7,8,9,10] (1934–1936) carried out many excellent experimental studies on rats twelve to eighteen days of age. He found decreased vascularity and increased calcification in addition to the previously described changes in cellular arrangement. He correlated the microscopic changes with gross skin effects and discussed theories pertaining to cell function and cartilage growth. Many bones receiving large doses underwent decalcification, spontaneous fracture and sterilization of cartilage growth. Baunach[2] described "cartilage necrosis" in young rabbits after irradiation with 1,650 r in divided doses. Bisgard and Hunt[3] (1936) found microscopic changes after doses only half as large as those required to stunt the bones of rabbits three to five weeks old, and stressed the lessening of effect produced by fractionation of the dose.

Gall, Lingley and Hilcken[22] gave excellent descriptions of detailed microscopic changes at varying intervals after stunting doses of 200 and 1,000 kv. roentgen rays delivered to the legs of rats fifty-four days old. They concluded that the ultimate effects produced were similar regardless of the type of rays used.

PURPOSE

Many, if not all, of these studies, despite contradictions, unconfirmed statements and reduplications, are of value today. The results obtained and the microscopic appearances noted, vary with different techniques, species and ages of animals used, amounts of radiation administered, and the interval between irradiation and necropsy. Many of the same structural changes have been described by more than one investigator, yet have been interpreted differently by

* From the Department of Radiology of the Presbyterian Hospital and of the College of Physicians and Surgeons, Columbia University, New York.

each. The interpretation of cellular changes is a highly individualistic function of each observer and constitutes one of the important reasons for the preparation of this paper.

It is the purpose of this study to describe and, wherever possible, to explain the histopathological changes accompanying various degrees of roentgen-induced stunting in rats of different ages.

INTRODUCTION

Sufficiently large amounts of roentgen or gamma rays bring about recognizable changes in every known kind of living cell.[6,18] The cells comprising certain tissues are very resistant to irradiation while others are readily affected. It is interesting that not all cartilage cells are alike in this regard.

Fibrocartilage and hyaline cartilage are resistant to large amounts of radiation.[19] The cartilage columns in the ends of growing bones, however, are remarkably influenced by and can be modified by quantities of roentgen rays which produce no grossly perceptible changes in the skin through which they pass. The cartilage in these locations is vitally concerned in the growth of the bone, and cellular change in cartilage is reflected in the bone produced. As Stump[43] has stated, "Bone formation is a secondary process of replacement and consolidation following in the wake of cartilage growth."

In a previous publication[24] I described the gross stunting of growing long bones following various amounts of roentgen radiation administered to rats from one day to six months of age. The present work is intended as a complement to the previous report as the histological material is, in large part, obtained from the same animals or their litter mates.

GENERAL TECHNIQUE (abbreviated)

Sherman strain albino rats of various ages were anesthetized, immobilized, and irradiated by a single dose of 200 kv., copper filtered roentgen rays at one sitting. The irradiated field was 5 mm. in diameter and included the right distal femoral growth center. The left femur of each animal served as the unirradiated control. The details of technique, as well as the rationale for the same, have been previously published.[24]

In some litters all animals were irradiated equally, and one member sacrificed every few weeks for microscopic study while roentgenograms of the survivors were made at intervals in order to obtain growth curves.

In other litters duplicates were run (i.e., each pair of animals received the same dose) and the doses for each set of duplicates were varied in order to study the effect of ascending amounts of radiation. In these experiments one animal from each pair was used for gross study while the other was sacrificed after appropriate periods to permit histological observations.

A considerable amount of the material here described was obtained when the growth studies were terminated, in some cases many months after the administration of the roentgen rays.

As the above mentioned necropsy material left some "gaps," other litters were subsequently irradiated and sacrificed at appropriate times to provide a continuous series of sections from the day of irradiation until nine months thereafter.

GENERAL PATHOLOGICAL TECHNIQUE

Both hind legs were disarticulated at the hips, partially freed of soft tissues, and placed in separate bottles, Measurements were made by roentgenograms or calipers or both before fixation. The bones were then fixed in Zenker's solution, decalcified by one of several standard methods, split longitudinally, imbedded in paraffin, sectioned at 6 micra and stained with hemotoxylin and eosin except for special purposes, which are specifically mentioned.

The arteries of a few animals were injected with India ink to identify blood vessels, while others received intraperitoneal trypan blue injections to facilitate identification of certain marrow cells.

BASIC ANATOMY AND PHYSIOLOGY

The anatomy of the epiphysis, cartilage zone and metaphysis has been thoroughly studied and is so well known that no detailed description will be given here. The physiology of endochondral bone formation is not yet entirely understood and is being investigated in many ways.

In order to simplify the following descriptive paragraphs and to avoid ambiguity of terms, as well as for convenience in designation, a normal illustration from Dodds[14,15,16] is shown (Fig. 1). Because of the great care and completeness of Dodds' work and his helpfulness in this study, we shall adopt the nomenclature and concepts of growth dynamics described in his writings.

As shown in Figure 1 there are five zones which can be readily recognized in actively growing cartilages.

Zone 1. Lying subjacent to the epiphyseal bone there is a narrow zone of "reserve cells" which divide to give rise to "row mother cells."

Zone 2. Columns of flattened discoid cells are formed by repeated divisions of the cells in Zone 1. This is the "zone of multiplication."

Zone 3. In this portion of the cartilage columns there is no cell division but growth of each cell progresses until it has lost its discoid nature and has become more nearly polygonal.

Zone 4. This zone is composed of fully grown cells and is usually only three to five cells wide. It is here that changes in the matrix occur and calcium salts are deposited in the longitudinal walls or septa between the orderly columns. The mineral salts are not deposited in the transverse septa of matrix between individual cells of the same column.

Zone 5. Here the vascular tongues of marrow advance along the rows of cartilage cells, removing the uncalcified transverse walls and liberating the cartilage cells from their lacunae. Some of the calcified longitudinal walls are subsequently removed but others remain as delicate trabeculae which act as the base upon which the developing new bone is formed. This "zone of chondroclasis" is narrow, as behind it comes the edge of advancing diaphyseal bone. Normally the calcification

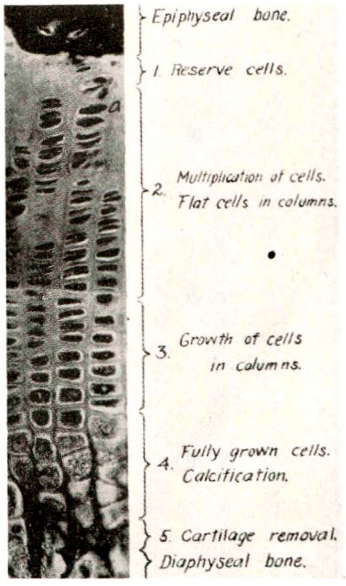


FIG. 1. Photomicrograph of normal growing cartilage. Five zones are described by G. S. Dodds, whose illustration is herewith reproduced from *Am. J. Anat.*, 1938, 55, 139.

advances into the cartilage columns only a few cell widths ahead of the marrow tongues which remove the cartilage. These processes are well balanced and orderly so that there is a constant relationship between cell multiplication, cell growth, matrix calcification, chondroclasis and deposition of new bone.

SECTION I

ONE MINIMAL STUNTING DOSE AT ONE MONTH

In the study of this material it soon became apparent that careful analysis of the histopathological changes was greatly complicated by several factors. These are: the amount of radiation, the age of the animal at the time of irradiation, and the length of the interval between irradiation and necropsy. These factors influence each other and exert a profound effect upon the histological changes in each section studied.

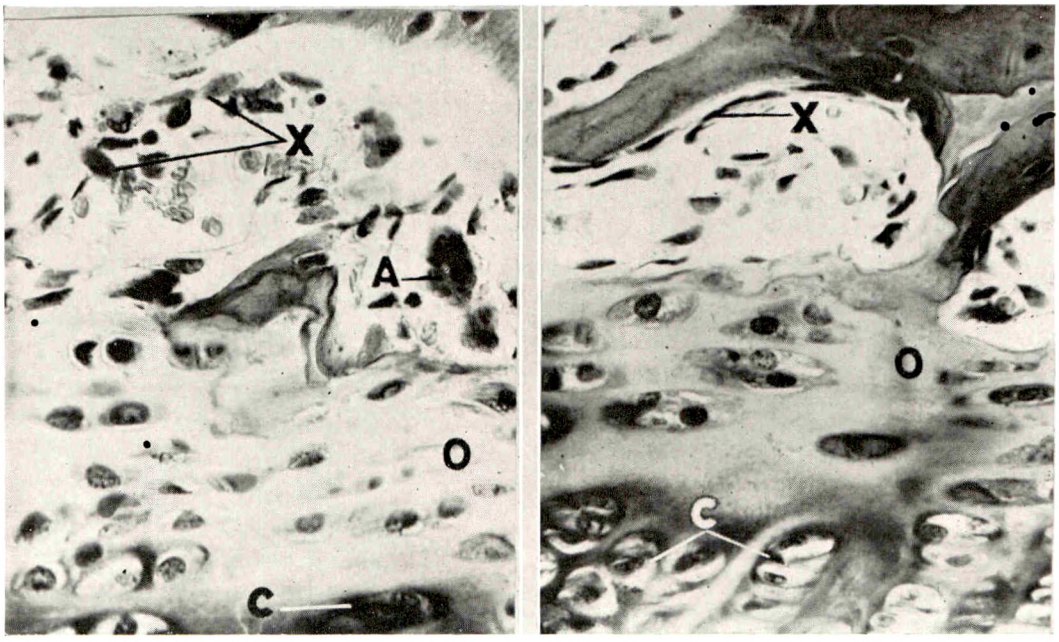


FIG. 2. *Zone 1.* Photomicrograph of Zone 1 and suprajacent epiphysis sixty hours after the administration of 600 r at thirty days of age (1 M.S.D.) (standard technique for Series 1). Animal No. 423. ×260. *Left*, irradiated; *right*, control. The cartilage cells (*O*) on the irradiated side are swollen and granular. Some nuclei stain darkly, others scarcely at all. Within the epiphysis (top) the osteoblasts (*X*) are degenerating and no longer hug the bone trabeculae. A multinucleated giant cell is present at *A*. Some of the cartilage cells of Zone 2 are included (*C*).

It is desirable in presenting this material to avoid complicating factors as much as possible, and to this end a single group of animals (Section 1) will be presented first. In the experiments from which the material in this section was obtained, the age of all animals was thirty days. Only females of normal weight were used and the dose was constantly 600 r (1 minimal stunting dose) in one sitting. The findings noted at increasing intervals after irradiation are described in such a manner as to provide a continuous chronological record of the changes transpiring after irradiation under these conditions. This dose at thirty days of age produces ± 10 per cent stunting in the ensuing month. For calculation of percentage stunting see footnote.*

* *Calculation of Percentage Stunting.* As previously pointed out, the degree of stunting alone cannot be accepted or regarded as an accurate measurement of the irradiation effect because of the different rates of growth in animals of different ages. Stunting of 3 mm. in a young animal is considered only a small amount because the normal bone grows with such rapidity that it quickly outdistances its fellow. In older animals stunting of several millimeters requires high doses of irradiation and may not become apparent for many months.

For this reason, in speaking of the amount of stunting, we believe that this should be expressed in terms of "percentage stunting" on the basis of the number of millimeters which the normal (control) bone grew over the interval included in the observation.

Calculation of the percentage of stunting:

Example: Animal No. 85

At the time of irradiation both femora measured 8 mm. (age 2 weeks).

At the time of necropsy the irradiated femur measured 22 mm. while the control was 33.5 (age 6+ months).

Subtracting 8 mm. (original length) we see that the irradiated bone grew 14 mm. while the control grew 25.5 mm. That is, the control grew 11.5 mm. more than the irradiated femur in a period of six months, or the irradiated bone was stunted 11.5 mm.

What percentage of the normal growth was the abnormal bone stunted?

$\frac{11.5}{25.5} \times 100$ equals the percentage

= 45 per cent stunting in six months.

HISTOPATHOLOGICAL CHANGES SIXTY HOURS AFTER IRRADIATION

The cartilage zones show the following changes which, while not striking, are definite:

1. The entire cartilage zone is increased

in thickness. This increase appears to be due to swelling of the cells. By actual count the average number of cartilage cells in a column at this age in irradiated and control animals is twenty-eight or thirty with no consistent difference in the irradiated and control bones. Zone 1 is definitely widened (Fig. 2) and the cells, instead of being fusiform, finely granular and homogeneously stained, are shortened, swollen, coarsely granular and, while some stain almost black, others are red. Many cells lie singly instead of in pairs, and short columns and a few empty lacunae are in evidence.

2. In Zone 2 the cartilage cells, which are arranged in small longitudinal groups of two to four, are very large and contain prominent knots of chromatin in addition to their nucleoli. While many of these cells are normal in aspect some have a stellate appearance, and others are shrunken and stain deeply. Here and there bizarre cells are seen, the nuclei of which are often multiple. There is a narrow clear zone just within the lacunae of the chondrocytes and the intercellular septa appear more distinct and darker staining than those of the controls.

In Zone 3 the cells show definite longitudinal derangement so that the columns, while partially preserved, are crooked and in places interrupted. The cells are large, pale and swollen. In morphology, these resemble the cells usually found in Zone 4. The lacunar margins are not rectangular but irregularly ovoid and stain deep purple. There is an increase in the amount and granularity of the interlacunar matrix which is finely fibrillar (Fig. 5).

Zone 4, which in the controls is about three to five cells in width, is found to be about five to seven cell thicknesses wide.

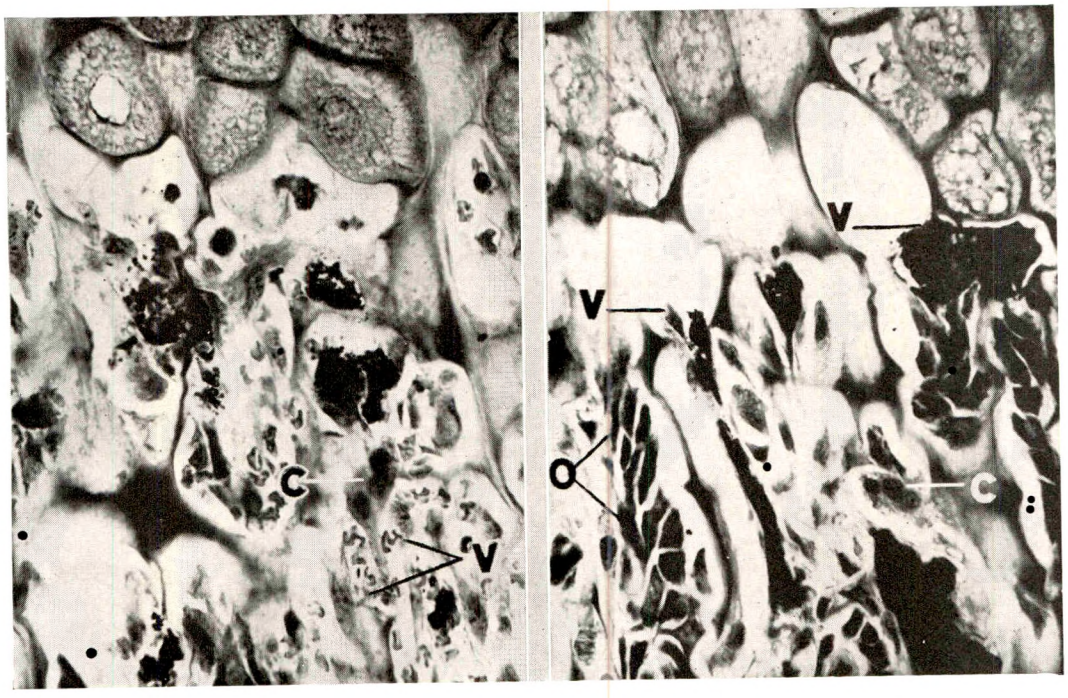


FIG. 3. *Zones 4 and 5.* Appearance three days after the administration of 600 r at thirty days of age (1 M.S.D.) Animal No. 504. ×260 (Series 1). *Left*, irradiated; *right*, control. The large vacuolated cartilage cells (top) are being invaded by blood vessels and connective tissue cells. On the irradiated side, the cells are disarranged and no distinct vessels can be seen, although red blood cells are present at *V*. No osteoblasts are identifiable although they are numerous in the control (*O*). India ink has been injected into the arteries, but although channels are present in the control (*V*) only a few granules of ink are present in the irradiated bone. Phagocytic cells are seen in both (*C*).

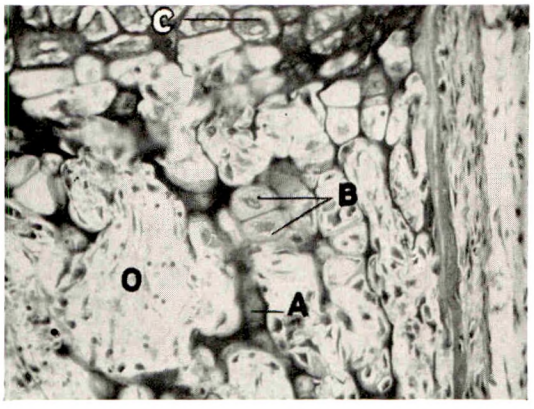


FIG. 4. *Metaphyseal Region.* One week after 600 r at thirty days of age (1 M.S.D.) Series 1. (animal H5. × 240). Large cartilage cells of Zone 5 are seen at *C*. The marrow (*O*) shows cellular destruction, derangement of osteoblasts and extravasated red blood corpuscles. Two well preserved cartilage cells within intact lacunae remain (*B*). There is advanced calcification of primary spicules (*A*).

The cartilage cells are considerably enlarged, some attaining twice the size of normal. A partially "empty" appearance is common and this in some cells is augmented by absence of the nucleus. The matrix substance is distributed unevenly between the cells which themselves vary in size and alignment. The matrix is slightly more heavily calcified in the irradiated bones than those of the controls, but the base (proximal margin) of the former is less regular. Instead of a fairly uniform, abrupt transition to calcific matrix material in the intercolumnar septa, this is irregular.

Zone 5 in the irradiated animals shows irregular chondrolysis and ragged perforation of the transverse interlacunar septa with the resultant production of "fraying" of the proximal cartilage margin. In some areas uneven sharp prolongations of unresorbed calcified matrix extend far proximally into Zone 5. In or adjacent to some of these are cartilage cells which have apparently escaped perforation and destruction. Conversely, extending distally from the diaphyseal bone, irregular spicules of bone and osteoid tissue are found. These appear to extend into the cartilage (Fig. 3).

In the most proximal portion of Zone 5 and in the metaphysis where normally osteoblasts are found perched upon the longitudinal bony and osteoid spicules, other changes are noted. These consist of disorientation of the osteoblasts which no longer are arranged in orderly fashion along the margins of the osteoid prolongations. These cells are found free in the marrow spaces where they mix with the general marrow population. In many areas they are curled into circular groups of ten or more about what resemble small blood vessels. Some of these cells are swollen and others are slender and fiber-like with pyknotic nuclei, but the predominant form is triangular. By morphology in section, these cannot be differentiated from the usual fibroblasts or immature connective tissue cells which are normally found in this location (Fig. 3).

In the marrow spaces the irradiation changes are readily apparent. There is haziness of many cells, and swelling, pyknosis and karyolysis of the marrow constituents. Red blood corpuscles are found outside blood vessels, hemosiderin granules are present, and the entire diaphyseal and epiphyseal region is less thickly populated than the controls.

The marrow changes, especially the depression of lymphocytes and normoblasts have been excellently described by others[5,27,29,41] and will not be discussed here. The blood vessel growth and distribution will receive particular attention later.

Although it is difficult to be certain at this stage, there is the impression that mineralization is augmented in the diaphyseal region of the irradiated bones. The diaphyseal cortical bone shows no changes which can be definitely attributed to the irradiation at this stage. The periosteum, epiphyseal bone, hyaline cartilage and extra-osseous tissues will not be discussed in this paper.

There is no gross stunting at this interval.

INTERVAL—ONE WEEK (FIG. 5)

Seven days after irradiation the cartilage zone remains wider than that of the control

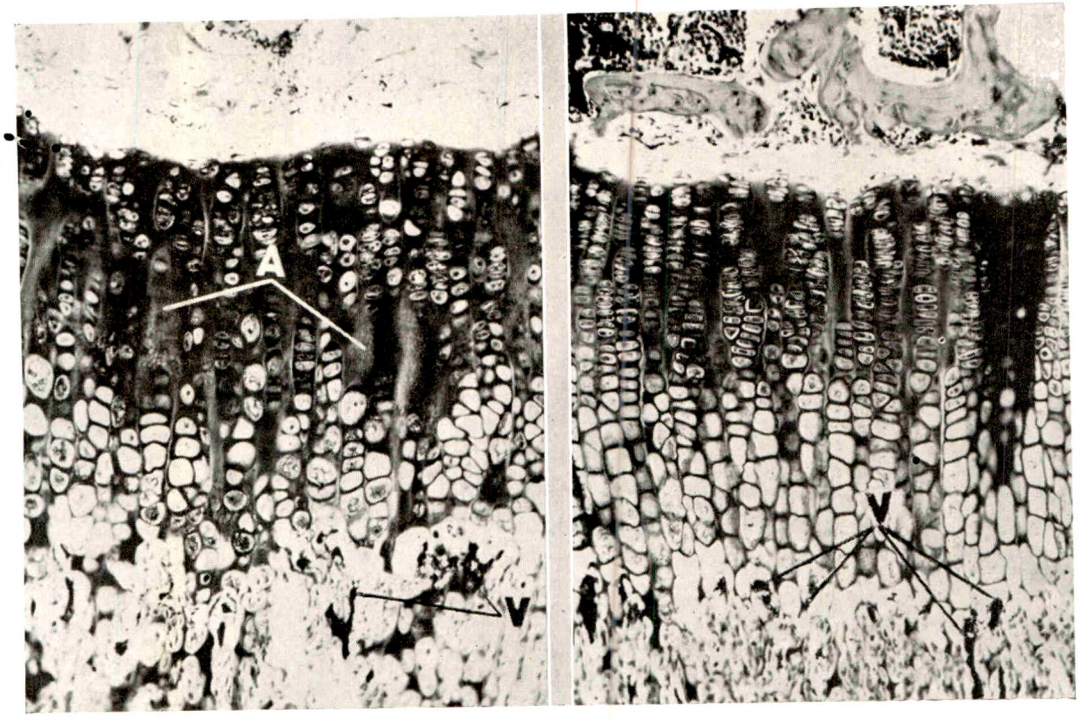


FIG. 5. *Epiphyseal Cartilage.* One week after 600 r at age of thirty days (1 M.S.D.). Animal No. 442. ×110. *Left*, irradiated; *right*, control. The bone has grown a normal amount in length but the cartilage cells are large, bizarre, poorly columnated and separated by bundles of fibrillar and granular matrix substance (*A*). The base of the columns is eroded irregularly and precocious mineralization has taken place in the metaphysis (bottom). The blood vessels (*V*) have been injected with ink but this section is not of sufficient thickness to permit accurate comparison of these structures. They appear disturbed in the irradiated metaphysis.

and contains three to four more cells per column. The cells of Zone 1 are predominantly ovoid and normal in size. They have a tendency toward abnormal polarity, however, and many lie parallel to the cartilage columns.

Zones 2 and 3 show much more marked changes. These consist of swelling of the cells, disarrangement of the cartilage columns, widening of the intercolumnar spaces, increase in the amount and granularity of the intercellular matrix and some degree of segmentation of groups of chondrocytes into ovoid bundles. These bundles are delimited by material which resembles that composing the lacunae. The cells themselves show enlargement, marked granularity, a definite trend toward eosinophilia, bizarre forms and nuclear fragmentation. Here and there a cell strains red, is retracted from its lacuna and does not appear viable.

Zone 4 contains many red staining cells and the same type of columnar disorganization described above. These cells are greatly swollen, granular, vacuolated, and are separated by unusually basophilic lacunar walls which appear thicker and more prominent than normal. These are heavily impregnated with mineral matter. The number of cells in column here is markedly inconstant, varying from four (normal) to ten. This produces a scalloped appearance of the proximal margin of Zone 4 and causes it to blend into Zone 5. Long, often crooked or branched extensions of unresorbed cartilage cells appear to reach deep into the metaphysis. Many of the proximal cartilage columns are seen to be normally invaded by delicate blood vessels and connective tissue elements while in contiguous areas the cartilage cells remain unchanged and unresorbed. In most cases it is found

that these persistent cartilage columns are invested by a dense layer of mineralized matrix. This shell is unusually scalloped or eroded, but the transverse intercellular septa are readily identifiable. It is not infrequent to find pairs or short chains of cartilage cells within intact lacunae, several cell widths proximal to the bases of the chondrocytes in Zone 5 (Fig. 4).

Marked changes are apparent in the marrow adjacent to the proximal cartilage prolongations. In addition to the changes in the hematopoietic system, there is an increase in prominence of red blood corpuscles and fat cells. There is a definite decrease in the number of osteoblasts. Many remain in recognizable form, however, and these are shrunken, pyknotic, karyolytic and unevenly distributed. At this age, normally, these cells do not only line the bony and osteoid spicules but practically choke the spaces between them (Fig. 3, control). They are plump, pale staining, finely granular and somewhat more numerous about blood vessels. In the irradiated bones they are slender, dark staining, show ragged protoplasmic extensions and lie irregularly scattered in the narrow spaces. Commonly they form tight whorls resembling multinucleated giant cells. The number of multinucleated cells, which are highly eosinophilic, is increased over the normal. They probably are macrophages as they take up trypan blue dye as previously shown.[8,40]

Osteoid tissue is found in the irradiated metaphyses but it appears to be decreased in amount and unevenly distributed. It sometimes constitutes a thick layer along one side of a bony spicule while the other side is uncovered.

The metaphyseal bone on the treated side shows certain interesting modifications. The bony spicules are broader, contain more blue staining mineral material and bear a closer resemblance to calcified cartilage cells than do those of the controls. They are branched, often fused, and show less regularity of spacing length and direction than normal. Here and there bony islands are found within which the calcified transverse and longitudinal lacunar walls of the obsolete cartilage cells stand out sharply. Another prominent feature is the presence of large plaques of heavily calcified, acellular matrix substance. Usually this is surrounded by a thin layer of osteoid tissue but in some instances these dense deposits are in direct contact with the marrow elements. The marrow cells at this time show active regeneration which is progressive hereafter.

Gross measurements at this interval show no stunting. It seems that the abnormal appearance is not associated with impaired growth function, although both femora have grown about 4 mm. since irradiation.

Interval—two weeks (fig. 6)

Two weeks after irradiation the width of the cartilage zone is normal except for the central fifth which is wide.

Zone 1 is not unusual.

Zone 2 appears to be divided into ovoid compartments delimited by pale staining fibrillar material. Within these compartments the cartilage cells are clustered closely. The cells are abnormal in appearance, show lack of columnar arrangement and contain prominent nuclear chromatin knots. Mitotic figures are so rarely found that they cannot be depended upon as an index of cellular activity.

Between the ovoid groups of cells the matrix substance forms large, deeply staining islands and wide bands which are much more prominent and presumably more heavily calcified than normal.

Zones 3 and 4 show some tendency to return toward columnar orientation of the cartilage cells but they are still irregular. The individual cells are larger than normal and show the heterogeny of staining, granularity and evidences of senescence described above.

In the central fifth of the epiphyseal cartilage plate it is evident that Zones 3 and 4 have still the appearance described at one week after treatment. There is little resem-

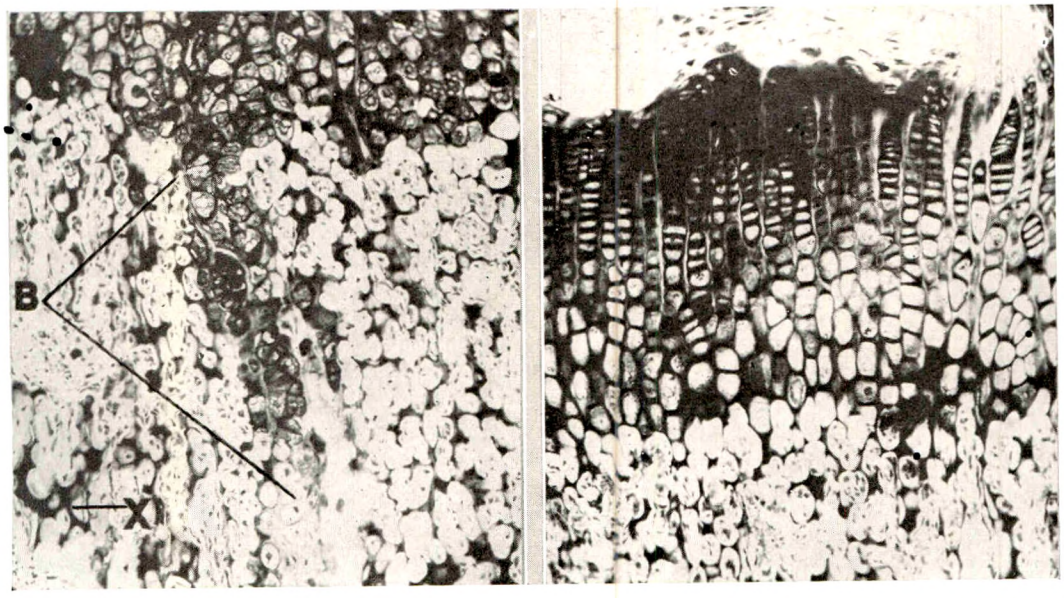


FIG. 6. *Proximal Cartilage Zone and Metaphysis.* Appearance two weeks after 600 r at age of thirty days (1 M.S.D.). Animal No. 414. ×110. *Left*, irradiated; *right*, control. Extending downward from Zone 5 (*C*) there is a broad finger-like process of unresorbed chondrocytes (*B*). This is in the mid-portion of the metaphysis, farthest from the blood supply. This is an exaggerated "cartilage tail" and is enclosed almost entirely by a rim of mineralized matrix. Mineralization of the primary trabeculae is heavy (*X*).

blance to the normal appearance or arrangement of cells and the thickness of the cartilage in the region is increased by about 30 per cent. This portion of the epiphyseal cartilage is farthest from the periosteal blood supply and is presumably the most poorly nourished.

In Zones 3, 4 and 5 also, the areas of fibrillar matrix substance are prominent. These appear to fill in the abnormally wide interstices between the irregularly spaced, crooked columns of cartilage cells.

Minerals are deposited in the usual fashion within the intercellular matrix of Zone 4, and in Zone 5 chondroclasis appears more orderly and more active but still deficient. The line between the large clear cartilage cells and the marrow spaces is irregularly jagged and, in certain areas, long irregular cartilage columns penetrate variable distances into the marrow cavity (Fig. 6). These cartilaginous extensions are not as numerous as those at one week but are considerably longer. Occasionally such a cartilage column appears almost intact, straight and uneroded. For convenience these are subsequently referred to as "cartilage tails." More frequently, however, portions of such columnar "tails" are found distributed in the diaphyseal region where normally non-cartilaginous bone spicules are being formed. Another type of prolongation which appears to extend proximally from the epiphyseal zone is that composed of totally acellular, calcium containing matrix material. Sometimes such prolongations fill the spaces between cartilage columns but frequently they are in contact with only marrow cells or vessels.

At this interval a marked change and regeneration are noted in the marrow cells, although there is still an increase in the amount of fat. Osteoblasts are now numerous and many are again found lining the spicules of bone and filling the intertrabecular spaces. Few of these appear abnormal either as to morphology or grouping. The fusion of osteoblasts described above is not present and the number of multinucleated cells is within normal limits

The metaphyseal new bone is of interest. It has a markedly irregular pattern to

which the following changes contribute:

(a) The above mentioned cartilaginous and matrix prolongations extend more or less deeply into this region.

(b) The width of the longitudinal bone trabeculae varies from two to five cells abreast.

(c) The direction of the trabeculae is abnormal, with many branching oblique and transverse trabeculae.

(d) Throughout the calcified new bone the pattern of the preformed cartilage is very clear, giving rise to a mosaic made up of large cell outlines which are calcified about their peripheries (Fig. 6 and 7). Many of these cells stain pink, some unquestionably represent previously formed osteoid tissue, but others are unmistakable cartilage cells.

(e) Scattered throughout the distal 1–2 mm. of diaphyseal bone, cartilage cells are found singly in pairs and short columns. Some of these cells show evidence of death or degeneration but others appear intact and morphologically normal. In most instances these isolated unresorbed cartilage cells are surrounded by a layer of calcified matrix.

(f) The above mentioned islands of calcified matrix are found extending several millimeters proximal to the epiphyseal line.

It is of interest that this peculiarly abnormal metaphyseal bone stops sharply about 2 mm. proximal to the cartilage plate. The diaphysis itself appears perfectly normal. Gross length measurements at this interval show a little less than 1 mm. of stunting of the irradiated bone. If it is assumed that this abnormal 2 mm. of metaphyseal bone is a result of the irradiation then it appears that longitudinal growth, although impaired, has continued despite the morphological abnormalities.

INTERVAL—ONE MONTH

One month after the irradiation injury there is a marked return toward a normal appearance of the cartilage zones. In Zone 1 no distinct abnormality can be made out.

Zones 2 and 3 show a definite columnar arrangement of the individual cells. The columns are not as straight as those of the control and appear tortuous or interwoven. The intercolumnar matrix material is more prominent than normal, dividing the cartilage cells into more or less isolated groups or bands. Here and there one finds a cell which stains red or brown, but in general the normal morphological characteristics of active cartilage cells are found. Frequently the flattened disc-shaped cells of Zone 2 appear concave on the side toward the epiphysis and a considerable number lie obliquely instead of in a plane perpendicular to the long axis of the bone as a whole. Infrequently one finds a huge, bubble-like cartilage cell surrounded by dense deep-staining matrix (Fig. 7). Usually such "cells" contain no recognizable nucleus or organized protoplasm, but occasionally they are found to contain two or more nuclei. Infrequent bizarre and pleomorphic cells are seen which are similar to those described earlier.

The abnormalities in Zones 4 and 5 are similar in nature to those described two weeks after exposure. The deviations from normal are less striking but extend a greater distance into the diaphysis at this time.

There is no longer a definite increase in the number of cartilage cells or length of the columns, but the blue staining matrix substance extends into the metaphysis in an irregular fashion, often surrounding a "tail" of cartilage cells which have retained their lacunae and staining qualities.

As a general rule, except for the matrix prolongations which are heavily mineralized, the zones of calcification and chondroclasis are quite normal in appearance. Delicate blood capillaries are found abutting upon the cartilage columns and the normal marrow elements (hematopoietic, fibroblastic, osteoblastic and endothelial) are found filling the spaces between the spicules of calcified matrix, osteoid, and new bone.

The outstanding abnormality is now found in the metaphyseal and diaphyseal new bone which is unevenly spaced and

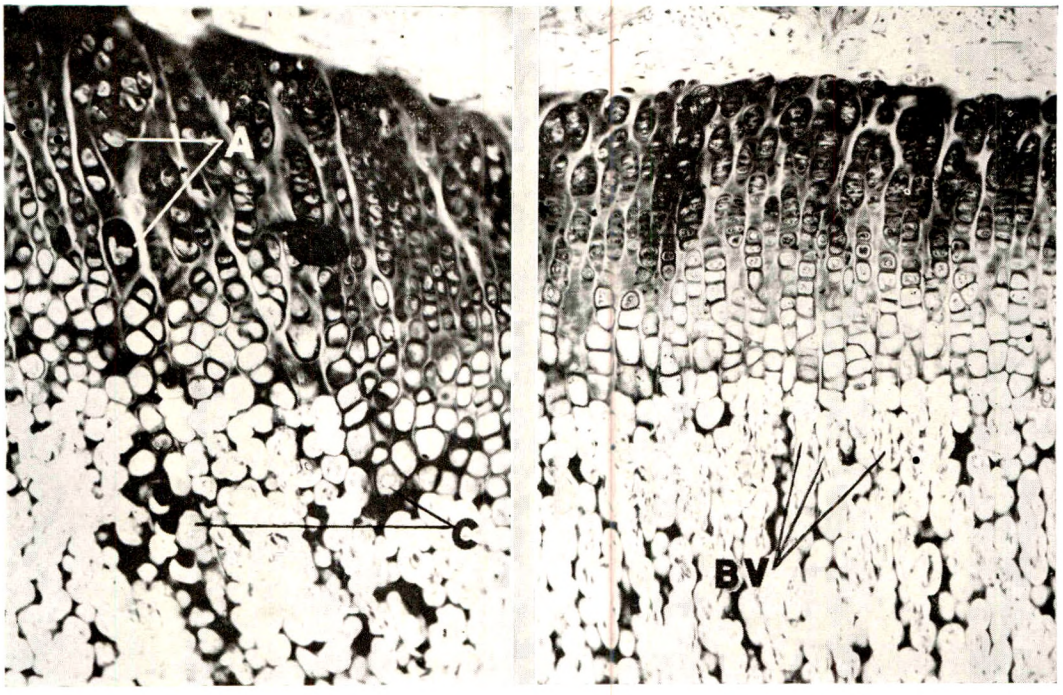


FIG. 7. *Cartilage Zone One Month after Irradiation.* Appearance one month after the administration of 600 r at age of thirty days (1 M.S.D.). Animal No. 415. ×110. *Left*, irradiated; *right*, control. The cartilage columns are still irregular and some cells are bizarre (*A*). The apparent increase in thickness of the cartilage plate is due to tardy chondroclasis of the "tails" at *C*. Although the blood vessels are not as straight and readily seen as those of the control (*BV*), they are numerous and appear to approach the cartilage columns as they should.

composed of spicules considerably wider and longer than normal. Within these heavy trabeculae the cell outlines of pre-existing cartilage cells are discernible due to the residual blue staining intercellular substance, producing a mosaic of transverse and longitudinal lines. The entire metaphysis of the irradiated bones is more heavily ossified than the same region of the controls (Fig. 7).

In almost every section from irradiated bones, a few recognizable cartilage cells are found incorporated within the cortical bone of the diaphyses several millimeters proximal to the epiphyseal line (Fig 11). Occasionally at such a location one may find unmistakable cartilage remnants or imprisoned cells distributed in linear fashion across the diaphysis, delimiting the normal zone from the abnormal. In the light of subsequent findings this vague line probably represents what was once the epiphyseal cartilage.

Gross measurements at this interval show between 1 and 1.5 mm. stunting of the irradiated femora.

INTERVAL—SIX WEEKS

Six weeks after irradiation the appearance is much like that at one month. The cartilage colunns are still deranged; the matrix substance is increased and heavily calcified; the hypertrophied cells of Zones 4 and 5 are large and at times atypical, containing eosinophilic cytoplasmic and nuclear inclusions, and chondroclasis is spotty and incomplete. The diaphyseal bone is abnormal in pattern and within its thick spicules vestigial cartilage cells appear. Osteoblasts and osteoid tissue line the bony spicules and the marrow appears normal as to constituents (except for slight increase in the number of fat cells). Delicate, normal appearing blood vessels filled with red

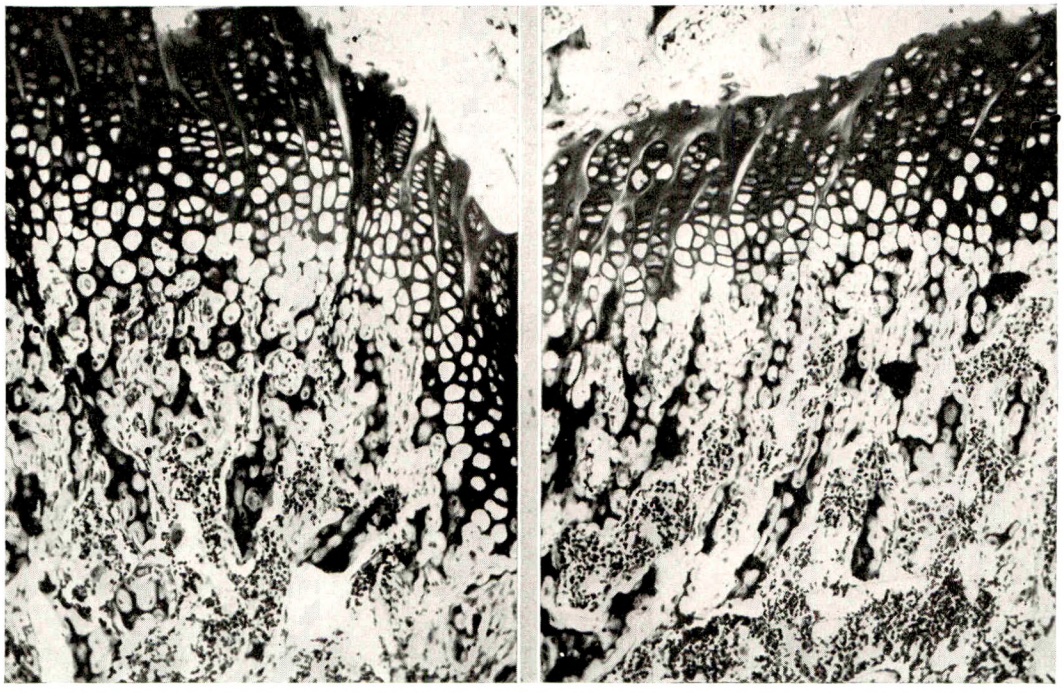


FIG. 8. *Growing Cartilage Zones Two Months after Irradiation.* Series 1. Irradiated with 600 r at thirty days of age (1 M.S.D.). Animal No. 303. ×110. *Left*, irradiated; *right*, control. The cartilage zone is wider in the irradiated bone, but columnation has been restored, the cells are practically normal in appearance, and there are but minor differences in the two pictures. Gross measurements show 1.5 mm. stunting of the irradiated femur at this interval, but the growth curve has returned to normal.

blood cells are found in approximately normal numbers and these extend distally to reach the zone of chondroclasis everywhere except in the areas where cartilage has not been destroyed. The atypical metaphyseal bone is now found to extend several millmeters farther proximal to the cartilage zone than it did two weeks earlier. This is evidently due to continued or resumed growth activity in a distal direction.

Gross measurements show that in the six weeks since irradiation the control femora have grown an average of 10.1 mm. while the irradiated ones have grown ±8.4 mm. (approximately 17 per cent stunting).

INTERVAL—TWO MONTHS

Two months after irradiation there is almost complete restoration of the columnar arrangement of the cartilage cells (Fig. 8). The marrow appears normal even to the fat content. Certain residual abnormalities are apparent, but these are noticed only on careful scrutiny. They consist of:

(a) Some irregularity in size and shape of cartilage cells and their nuclei, with a tendency toward large cells. Zones 4 and 5 are slightly wider than normal due to the presence of one or two excess large cells at the bases of the columns.

(b) Blunting or clubbing of the growing cells in Zone 2, which are separated by wide strands of matrix.

(c) A few irregularly distributed short and infrequent long "cartilage tails" persist in situations where chondroclasis is imperfect.

(d) The matrix is more prominent than normal and heavily calcified, forming dense finger-like processes which extend proximally into the metaphyseal zone.

(e) Prominent, wide, calcified trabeculae of new bone in the metaphysis. In this new bone one can no longer identify unresorbed cartilage cells as such, although the mosaic which is present suggests that they may

tion. Some unusual manifestations will be commented upon below.

PATHOLOGIC HISTOLOGY IN ANIMALS IRRADIATED VERY YOUNG

In animals irradiated under one month of age, microscopic changes are noted as early as forty-eight hours after irradiation (1 M.S.D.). The changes are very similar to those described in Section 1 and will not be reviewed in detail. At this age the cartilage columns are very long and the marrow elements and blood vessels in the metaphyseal zone are richer than at any other time. For this reason, apparently, the changes are very marked on cartilage, new bone, blood vessels and marrow cells. Figure 9 shows marked swelling and cellular derangement of the cartilage and marrow. The recuperative processes, however, are most active in animals of this age group and these may be recognized within a few days of the irradiation, seemingly synchronous with the destructive effects. The rapid regeneration is most readily recognized in the marrow cells, which show only a very transient diminution in number. Animals irradiated when one day of age showed 16 to 20 per cent gross stunting when sacrificed three months later, but microscopically at necropsy the cartilage, bone, marrow and vessels appeared entirely normal.

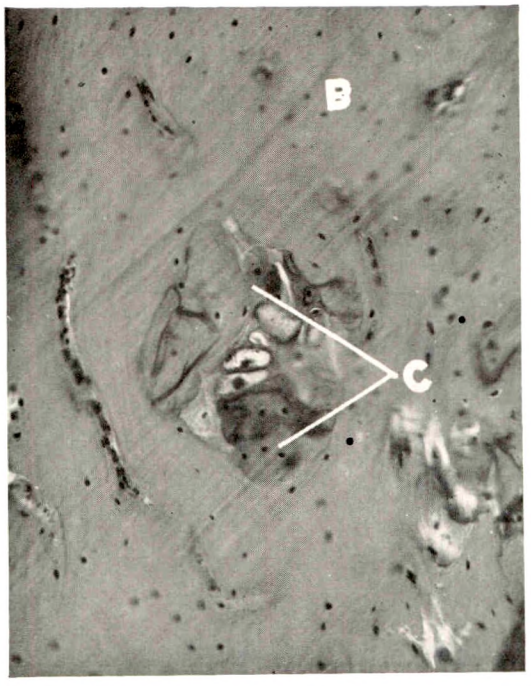


FIG. 11. *Cartilage Cells, Trapped within the Cortical Bone of the Diaphysis.* This animal received 500 r at two weeks of age (1 M.S.D.). The section made three months later shows several well preserved chondrocytes (*C*) incorporated into the shaft (*B*) 4 mm. proximal to the epiphyseal line. Animal No. S2. ×240.



FIG. 10. *Recovery after Heavy Irradiation in Infancy.* Irradiated with 1,000 r (2 M.S.D.) at eleven days of age. Section made eight months later. ×40. Animal No. 86. The marrow, blood vessels and epiphyseal cartilage are all normal for an animal of this age. The bone trabeculae are, however, heavier than normal and a typical nest of cartilage cells has been incorporated into the bone at *K*.

An interesting feature in this age group is the tolerance of the tissues to excessively high doses. Animals irradiated with as much as 3 M.S.D. at the age of eleven days (infancy) developed marked stunting (as much as 45 per cent), yet when the bones were examined by section six months or more later there was practically no abnormality of the cartilage of the growing femur which had been so heavily irradiated (Fig. 10). In such bones, of course, it is possible to find residual effects of the irradiation,

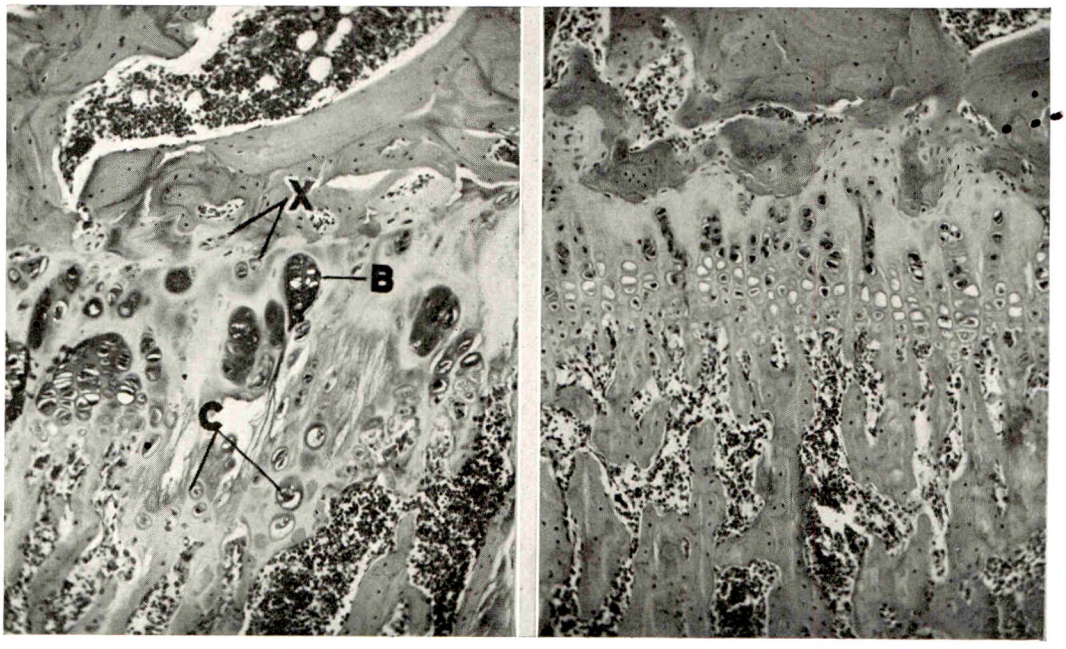


FIG. 12. *Regeneration of Epiphyseal Cartilage.* Animal No. 101 received 1,350 r at six weeks of age (1.5 M.S.D.). The section was made three and a half months later. ×110. *Left*, irradiated; *right*, control. Club-shaped groups of chondrocytes (*B*) are growing in an environment of excess matrix. "Cartilage tails" have not yet been entirely resorbed (*C*). Zone 1 shows proliferative activity of the cells at *X*.

either in the fat or fibrosis of the marrow or abnormally laid down diaphyseal bone proximal to the cartilage zone. When these distinctive abnormalities are found several millimeters proximal to the epiphyseal cartilage, it is assumed that these several millimeters of bone distal to the changes grew subsequent to the irradiation (Fig. 14 and 18). Figure 11 shows cartilaginous remnants within the diaphyses 4 mm. proximal to the growing cartilage.

ANIMALS IRRADIATED ONE AND ONE-HALF TO THREE MONTHS OF AGE

Animals one and one-half to three months of age at the time of irradiation show effects of irradiation and changes of growth physiology intermediate between those just described and those of the older age group which will be taken up next. A typical example is seen in Figure 12 which is a section of a femur irradiated with 1.5 M.S.D. at six weeks of age. The animal was sacrificed three and one-half months later. This animal showed 15 per cent stunting but was growing again at the time of necropsy. In spite of the obviously abnormal appearing cartilage zone there is gross and microscopic evidence of growth activity and cartilage proliferation. There has been a definite return toward columnar arrangement although the cartilage cells are clustered in club-shaped groups separated by wide matrix bands. The individual cells vary in size, shape and staining qualities, imparting a very abnormal appearance to the epiphyseal cartilage. It is noteworthy, however, that chondroclasis, although imperfect, is going on, the vascular tongues and marrow cells extend to Zone 4 and new diaphyseal bone has been laid down, imprisoning a number of scattered, unresorbed chondrocytes. All of these findings, together with grossly measurable growth in length, indicate a partial return of the normal processes of endochondral growth function. When the interval is lengthened several more months before necropsy there is even more complete recuperation.

In Figure 14 (low power photomicro-

graph) there is unquestionable evidence of resumption of growth and return toward normal histology. Here injured cartilage cells form an almost complete transverse band across the diaphysis at C1. The actively growing cartilage zone has advanced to position C2. Higher power studies of these two zones (Fig. 15 and 16) show the imprisoned and partially ossified cells of C1 and the resumption of columnation, vessel invasion and osteoblastic activity of C2.

If the dose is raised sufficiently to more severely injure the cells of this region, then this return of normal physiology is delayed.

Figure 13 shows the interesting appearance of the abnormal cartilage zone, fatty fibrosed marrow, and bony sclerosis of the metaphyseal region in a bone which received 2 M.S.D. at two and one half-months of age. The section was made at the age of five months. The cartilage represented by bizarre cells, almost all of which are larger than normal and appear hypertrophic or senescent. Zones 4 and 5 are not distinctly identifiable as the cells in them are of the same variety. The base of the cartilage zone is sharply outlined by a dense calcific line, which is also seen outlining some of the thick, dense trabeculae of new bone in the metaphysis. Within the fatty marrow only a few cells are seen but these do not appear abnormal. There are blood vessels near the cartilage zone but these are larger than any normal vessels ever found in this location and appear more like vascular lakes than true vessels. No normal, delicate, linear, thin-walled capillaries are found in the situations in which they belong. No recognizable osteoblasts or osteoclasts are present in the irradiated area, and the spicules of new bone are not lined in the usual fashion by osteoid tissue. Serial roentgenograms show that this bone was stunted 90 per cent in the two and one-half months following

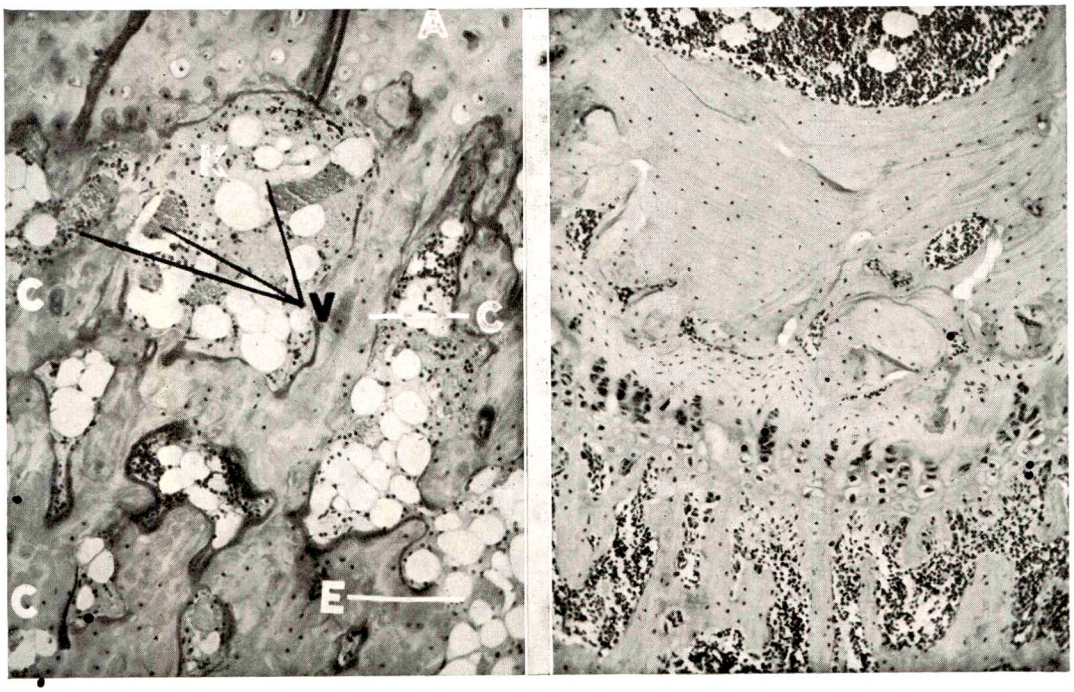


FIG. 13. *Marked Injury to Cartilage, Marrow and Blood Vessels.* This animal received 2,000 r at age of two and a half months (1.66 M.S.D.). Section made two and a half months later. Animal No. 224. ×110. *Left*, irradiated; *right*, control. The abnormal cartilage of Zones 4 and 5 is shown at *A*. A narrow line of densely mineralized tissue separates the cartilage from the marrow. A similar line bounds the heavy bone trabeculae (*C*) of the metaphysis. The marrow (*E*) is fatty. Three large lake-like blood vessels (*V*) are in the marrow but none approach the cartilage. Growth at this time has not been resumed.

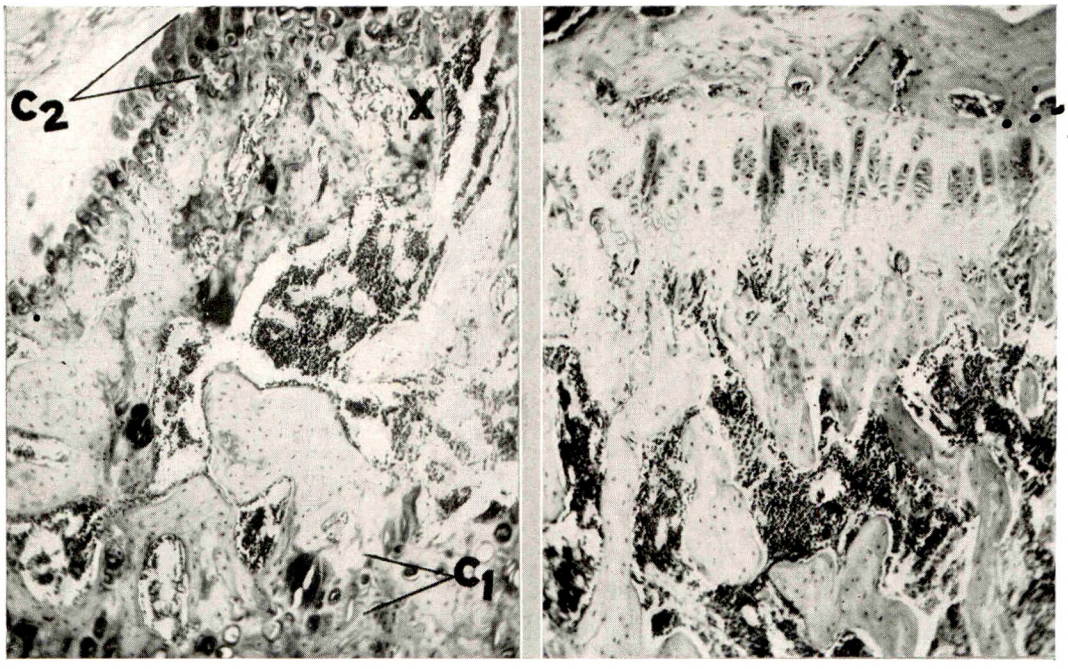


Fig. 14. *Double Epiphyseal Line Found after Growth Resumption.* Animal No. 253 received 1,500 r at three and a half months of age (1 m.s.d.). Section made two and a half months later. ×90. *Left*, irradiated; *right*, control. Remnants of what was probably once the active epiphyseal line at the time of irradiation are seen at C_1. These cells extend across what is now the diaphysis. Due to regeneration and distal migration of the growing epiphyseal line, growth is now going on at C_2. Gross measurements by roentgenograms show that the irradiated femur is growing more slowly than the control.

irradiation. Microscopically, however, there is evidence of cellular activity and cartilage growth in Zone 1, and litter mates of this animal which were allowed to live longer show more evidences of recovery.

IRRADIATED AT AGES FOUR TO SIX MONTHS

Animals treated at from four to six months of age react somewhat differently to irradiation and present certain interesting findings.

In this age group the amount of roentgen radiation required to produce measurable stunting is quite large (1,600–2,000 r) and, as might be expected, such doses cause marked marrow, fatty and vascular changes. In some cases atrophy of the marrow cells, increased marrow fat and destruction of the intraosseous capillaries are found without the production of measurable stunting. Doses capable of stunting growth produce cartilage changes in general similar to those of the younger ages but the excess matrix calcification, formation of "cartilage tails," widening of the cartilage zone and disturbances of columnar arrangement are not as striking. Here the most marked effect is on Zones 1 and 2 which become almost free of proliferating cells, while Zones 3, 4 and 5 do not show much disturbance. One or two months later the cartilage zone looks distinctly abnormal (Fig. 17) but the columnar arrangement is retained and by this time there is definite proliferative activity in Zones 1 and 2. At about this interval or a little later it is notable that the cartilage zone is bounded proximally and distally by very dense bone. This appears to "hem in" the cartilage and to bound the margins of the trabeculae near by. These trabeculae are not covered by osteoblasts or osteoid tissue as they normally are.

The marrow changes are not necessarily permanent, for in animals irradiated as late as four and one-half months sections two

and one-half months later show almost complete regeneration of the marrow with persistence of the abnormal cartilage zones. The cells of the latter stain poorly and vary in size and shape, but tend to be larger than normal. Many of the bizarre cartilage cells contain eosinophilic cytoplasmic inclusions similar to those described earlier (Fig. 12, 13 and 17). These unusual looking cells are distributed somewhat irregularly in an excessive amount of pink staining matrix substance, but there is partial retention of the normal columnation.

The proximal margin of the cartilage zone in such animals is not serrated and invaded by marrow cells and blood vessels but ends abruptly in the dense transverse bony plate mentioned above. There are no true hypertrophic cartilage cells of Zones 4 and 5 and there appears to be little or no activity at the bases of the columns while proliferation is unquestionably going on in Zone 1. This is so marked in some specimens that Zone 1 constitutes almost 50 per cent of the entire cartilage thickness. These active cells are small, normal staining, grouped in twos and threes in the plentiful matrix, and bear a definite resemblance to hyaline cartilage cells (Fig. 18). At this interval there is no abnormal, newly formed diaphyseal bone, and the assumption is that little or no growth in length has taken place. (Gross measurements also show that the stunting plateau at this age is two to three months.)

At longer intervals after irradiation (4–9 months) other interesting manifestations are found. If the dose has not been excessive there is progressive reappearance of the normal marrow constituents although some excess fat always persists.

The activity of the cells in Zone 1 appears

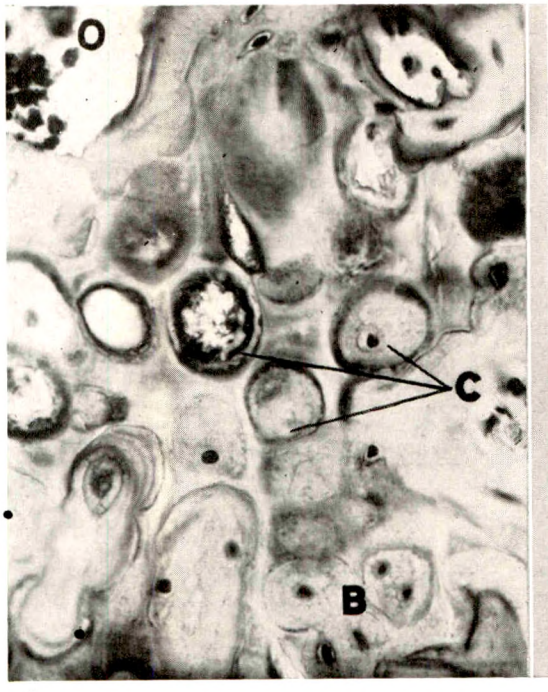


FIG. 15. *Photomicrograph of Zone C_1 in Figure 14.* ×260. The chondrocytes have in part been ossified (*B*) although some retain their chondroid characteristics (*C*). This zone is bounded by normal marrow cells (*O*). There is no evidence of regeneration of growth among these chondrocytes and they are probably being converted into bone.

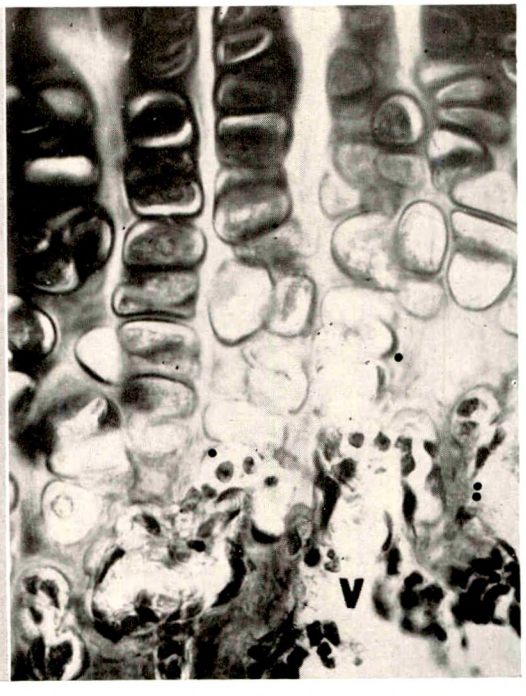


FIG. 16. *Photomicrograph of the Growing Epiphyseal Line C_2 in Figure 14.* ×260. These cartilage cells probably represent the survivors of the irradiation injury. They have migrated distally, reformed columns, and are carrying on the growth function. Vessels, osteoblasts and other marrow cells are clustered about the columns at *V*.

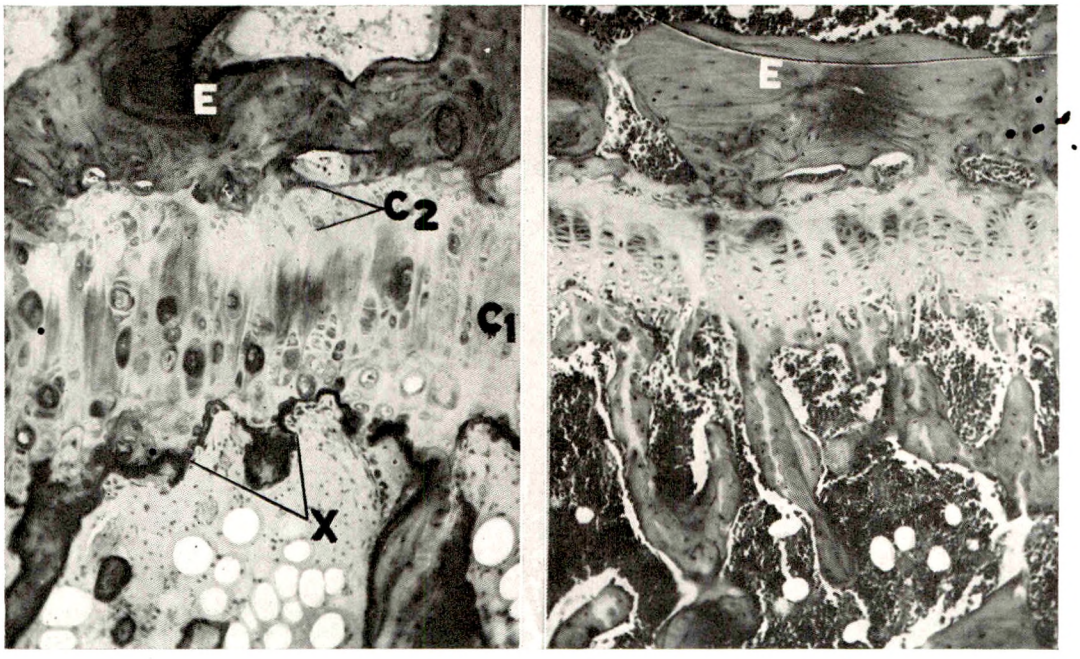


FIG. 17. *Bone Irradiated Well Past the Age of Active Growth.* Animal No. 62 received 2,500 r (1 M.S.D.) at the age of six and a half months. Section was made two and a half months later. ×110. *Left*, irradiated; *right*, control. The epiphyseal bone is knurled and sclerotic (*E*); the marrow is fatty, avascular, fibrosed and separated from the abnormal cartilage (C_1) by a densely mineralized line (*X*). In spite of these marked changes young proliferating chondrocytes are found at C_2. This proliferating zone is wider and more active in the irradiated femur than in the control. If sufficient time had elapsed for the cells of C_1 to migrate, this section would presumably resemble Figure 14.

to result in distal progression of the cartilage zone, but in most cases these new cells fail to take on the true columnar arrangement of growing younger bones. The "hyaline-like" appearance persists with some tendency toward the formation of short columns only. Those cells farthest from the advancing margin are larger than those of Zone 1, yet their septa are not calcified in the normal manner and they are not subjected to normal chondroclasis at the bases of the colunns.

Adjacent to these larger cells, instead of a zone of active marrow elements and budding capillaries, there is again found the densely calcified, transversely lamellated bone which appears to segregate the cartilage band from the marrow cavity (Fig. 13 and 17). Next to this dense transverse bone, or often incorporated within it, there are remnants of cartilage cells which appear to have had calcium deposited about them. Throughout this terminal diaphyseal bone the pattern of pre-existing chondrocytes is so clear as to suggest that the non-resorbed cartilage cells of the growing epiphyseal line served as the nidi for the building of new bone (Fig. 18).

Proximal to the advancing cartilage zone in many bones one finds a great number o easily recognizable ghost-like cartilage cells. These in some cases are closely packed or arranged in short columns. Occasionally such a band of obsolete chondrocytes stretches almost all the way across the marrow cavity, forming a secondary, inactive epiphyseal line (Fig. 19). When one recalls the evidences of deficient chondroclasis in young bones it is not difficult to appreciate that these cells are the remnants of the previous epiphyseal line, the surviving components of which have now migrated distally. Most or all of these cells left behind are presumably dead, but due

to deficient chondroclasis they were not removed and served as a framework for the deposition of new bone, into which they are now incorporated.

In retrospect and by careful searching I have found evidence of this proximal "ghost epiphyseal line" in a great many specimens. It is a fleeting finding in young bones where recovery and reparation are rapid, but persists for months in older animals which received doses sufficient to stunt the bones without producing permanent growth cessation.

If the dose administered is too great (2 or more M.S.D. at an age past the period of active growth), the injury to all the cells may prove to be too severe to permit recovery. In such cases, even as long as six or eight months after irradiation, sections disclose non-vital cartilage bounded by devitalized, sclerotic, friable bone and fatty, fibrous, avascular marrow. In bones thus injured, gross measurements and microscopic evidence together indicate veritable sterilization of growth function (Fig. 20).

CHANGES IN NON-CARTILAGINOUS ELEMENTS

Osteoblasts

The cells known as osteoblasts, which normally lie end to end about the periphery of the newly forming bony spicules subjacent to the cartilage zones, are worthy of special attention. The function of these cells remains a source of controversy, and for this reason it is well to note the effects of roentgen irradiation upon them.

Four or five days following administra-

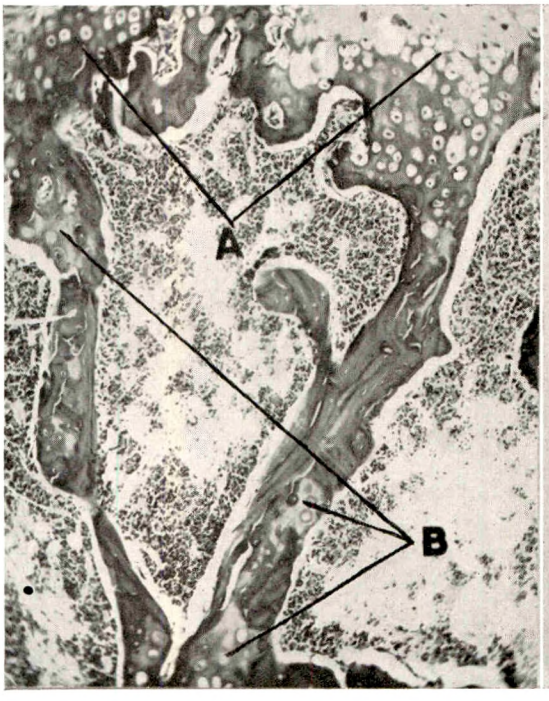


FIG. 18. *Metaphyseal Bone Formed after Irradiation in Adult Life.* This animal received 2,500 r at four months of age (1.5 M.S.D.). Section made six months later. Animal No. 111. ×110. The advancing cartilage (top) is trailed by cells resembling hyaline cartilage (*A*). The marrow is cellular but hypovascular. The heavy trabeculae of bone contain islands of chondrocytes (*B*) which are being ossified. Gross measurements show that this bone has grown several millimeters since irradiation.

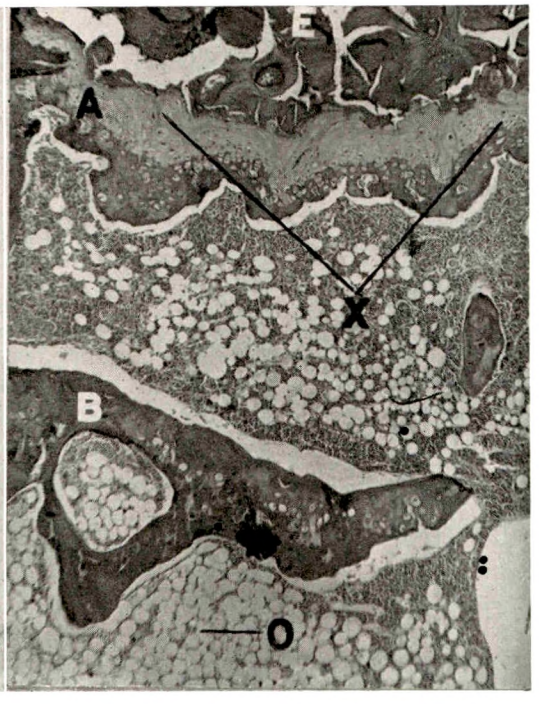


FIG. 19. *Double Epiphyseal Line.* Another portion of the same bone shown in Figure 18. ×60. Here there are clearly two epiphyseal lines, one actively growing (*X*), and one incorporated into a transverse chondroid-osseous transverse barrier (*B*). Few vessels are seen in the fatty marrow (*O*).

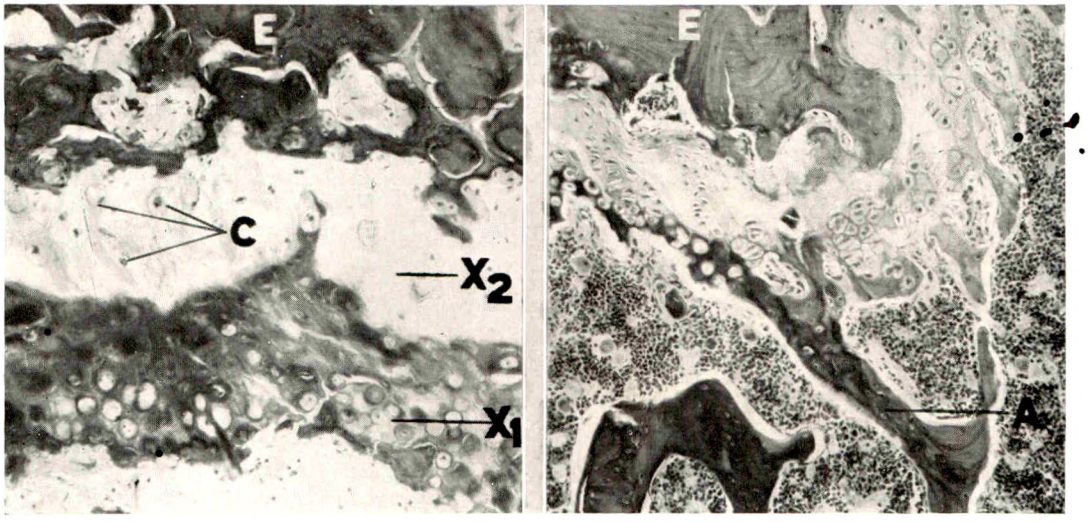


FIG. 20. *Roentgen-Induced Sterilization of Growth.* This animal received 3,000 r at four months of age (2 M.S.D.) after the period of most active growth. Animal No. 105. ×110. Section made six months later. *Left*, irradiated; *right*, control. Devitalized cartilage (X_1) lies within a wide zone of mineralized but not ossified matrix. The cartilage band (X_2) contains only a few cells which have migrated a short distance toward the epiphysis (E). Although some of these are well preserved (C), there is no proliferative activity. This appearance, together with gross measurements, indicates cessation of growth. In the control, the heavy ossified trabeculae (A) and irregular epiphyseal cartilage are normal at this age (ten months).

tion of 1 M.S.D. to animals one month old there is a definite change in the osteoblasts. They become separated from their bony bases and lie free in the marrow cavity. Frequently they are swollen, granular and eosinophilic, but some appear flat and pyknotic. Commonly these more or less triangular cells are found clustered about a small blood vessel, where they resemble ordinary fibroblasts or immature connective tissue cells (Fig. 2, 3 and 4). The number of cells which can be identified as osteoblasts by their situation, shape and staining qualities is markedly diminished. At this time there is a notable scarcity of the noncalcified organic "osteoid tissue."

In the ensuing week or ten days there is a definite return toward normal both in number and situation of these cells. Their reappearance parallels the regeneration of the marrow cells.

Three weeks after irradiation of this magnitude finds the osteoblasts normal in section. They now again form the peripheral zone of cells about the bony spicules. In addition, however, they envelop the above mentioned strands of calcified matrix and islands of unresorbed cartilage cells found trailing after the advancing epiphyseal line. When osteoid tissue is deposited upon such a sturdy framework and is converted into new bone, the latter is broader and heavier than usual. This is a possible explanation for the heavy dense trabeculae of metaphyseal bone described above (Fig. 7). Gall, Lingley and Hilcken,[22] who also noted this heavy new bone, prefer to explain this on the basis of increased osteoblastic activity.

After higher doses and in older animals, the reappearance of these cells is slower and often deficient. In such bones, examined several months after irradiation, it is common to find the metaphyseal bone completely bare of osteoblasts and osteoid. Under these conditions the bone and often the cartilage are rimmed by densely mineralized material totally different from the deposition of normal new bone (Fig. 17).

One must be careful to differentiate between mineralization of matrix substance and true ossification.[30,42] When we spoke of excess mineralization in the early phases of

this paper we meant just that, and not increased osteoid formation or true ossification.

Growth in the Absence of Osteoblasts

In the bones receiving enough roentgen rays to practically sterilize cellular activity, cartilage cells and matrix substance became heavily calcified, forming a dense, friable layer of pseudo-bone proximal to the epiphyseal line (Fig. 20). Here there are certainly no functioning osteoblasts, and no evidence that any have been present since their abolition by the roentgen rays. With the exception of the cartilage cells which were not resorbed, the fat cells and ordinary connective tissue elements, there are no cells which could conceivably take part in the transition to bone. Dawson[12] has described direct change from cartilage to bone in old rats, and Dodds and Cameron[16] have written of similar changes in healing rachitic bones. It is quite possible that this is the process in operation here.[15] The wide, dense heavily calcified transverse band of friable material, also described by others,[22] is not true bone, but it has formed, presumably after irradiation and without the assistance of osteoblasts or the preliminary laying down of osteoid tissue (Fig. 13, 18 and 19). In the bones showing two distinct epiphyseal lines, separated from each other by 1 or 2 mm., it is assumed that this small amount of growth in length occurred as a result of mere calcification in the wake of the advancing epiphyseal line.

VASCULAR CHANGES IN ROUTINE SECTIONS

Each section was studied with special reference to blood vessels. There are, however, certain weaknesses of such a study: (1) the section may be taken at such a level as to strike more or less vessels than are found in the control; (2) the vessels are delicate and difficult to identify; (3) many can be recognized only by the red blood cells within them; (4) in thin sections the cells are often washed out during the technical procedures involved in preparation of the slide.

The extra-osseous blood vessels are affected in the manner previously described in the skin and elsewhere.[11,17,28] These changes are limited to the intima and media and in no instance is there any appreciable decrease in the lumina or evidence of thrombosis or stenosis of the femoral or tibial vessels.

A. Low Dosage in Young Animals. The intra-osseous vessels show some engorgement and diapedesis or hemorrhage a few days after 1 M.S.D. (Fig. 3). After an interval of a week no abnormalities can be made out. After two weeks, in the majority of sections there is an apparent diminution in the number of delicate end capillaries which reach the bases of the cartilage columns, although the vessels found in this location appear normal in caliber, content and function. It is interesting that the areas of most marked cartilage disarrangement and deficient chondroclasis (i.e., the central portion of the growth zone) are also the areas in which the vessels are scarce or absent.

A month or more after irradiation of this degree, distinct abnormalities of the vascular system are no longer apparent.

B. Heavy Irradiation. In the bones receiving higher doses, especially in the older age groups, there are marked vascular changes even as late as eight months after irradiation. These alterations vary from a barely perceptible diminution in number and caliber to almost absolute avascularity in the irradiated areas. Hemosiderin deposits are frequent. Many of the bones showing the fatty, fibrosed marrow described above, exhibit only tiny thin-walled vessels which course through the fat at wide intervals, never approaching the cartilage zone (Fig. 17). In bones showing the "double epiphyseal line" it is common to find the vessels larger than normal proximal to the original epiphyseal line but scarce or absent distal to it. At long intervals after irradiation it is common to find the vessels of the diaphysis forming large thin-walled vascular lakes which cause an apparent increase in vascularity (Fig. 13).

By closer inspection, however, one finds that the number of vessels running longitudinally as well as their average caliber is diminished. In the bones subjected to large doses, it is generally true that if the marrow cells have regenerated the blood vessels are relatively normal. There are some instances, however, in which the marrow appears healthy and only an occasional vessel is found approaching the cartilage which is separated from the marrow by the above mentioned densely calcified transverse wall.

A more careful and adequate study of the size, distribution and number of blood vessels in the metaphyseal regions of irradiated bones will be subsequently reported.

DISCUSSION OF POSSIBLE MECHANISMS INVOLVED

Probably the histopathological changes can best be explained on the basis of an immediate direct effect and a secondary or indirect influence.

Direct. It appears logical to assume that the early manifestations of swelling, granularity and loss of columnar arrangement noted very soon after exposure to roentgen rays are manifestations of direct irradiation effects upon the cartilage cells themselves.

Direct effects may also account for the increased amount and granularity of the intercartilaginous matrix substance. The reason for the excessive precipitation of minerals in the matrix and intercolumnar septa is not clear. It may be due to a change in hydrogen ion concentration, but as Rous[37] has pointed out the pH of cartilage is passively determined by its environment. It has never been possible, either by electrodes or vital dyes, to determine normal pH values for the various components of the complex growth zones, and we can therefore only assume that roentgen irradiation may alter these values. Kleinmann[26] has stated that increased alkalinity is present in devitalized tissues, which change favors the precipitation of calcium salts. If one accepts the common theory that hypertrophic cartilage cells augment mineral deposition, then the large vacuolated cells of Zones 4 and 5 described above, plus a possible shift toward alkalinity, may offer the explanation for the precocious mineralization here noted.

There is no reason to doubt that the effect upon the end capillaries is a direct one.

It is also probable, but not certain, that the damage promptly inflicted on the marrow cells (including the osteoblasts) is a direct effect.

The temporary retardation of growth by roentgen irradiation produces certain modifications apparently identical with those "lines of growth arrest" resulting from other causes. Harris,[23] in his description of the bone changes in acute infections, states that "any case presenting arrested growth will display an increased deposition of calcareous matter in the transoms of the calcified zone and in the transverse trabeculae of the adjoining osseous zone." He also writes, "the line of growth arrest becomes incorporated in the diaphysis as soon as growth in length is reestablished." One can see at once that these statements apply also to the stunting caused by roentgen irradiation. How much is a direct and how much an indirect effect must remain conjecture.

Indirect. Due to the decreased size and number of blood vessels, there is not only a relative anoxemia but also interference with mechanical erosive function. This is clearly evidenced by failure of the vessels to invade the large cartilage cells in Zone 5. When the vessels deviate from their normal direction and run obliquely or transversely through the metaphysis, the functional effect is shown by deficient cartilage and matrix resorption and in the subsequent deposition of new bone. Cartilage and matrix prolongations and islands found in the metaphysis after the epiphyseal line has migrated distally correspond to avascular areas not penetrated by vessels. Perhaps the capillaries cannot gain access to the cartilage because of the heavily calcified matrix, but it appears more plausible to assume a direct action upon the vessels.

These unresorbed cartilaginous remnants bear a close resemblance to those found in

identical situations in healing rickets. These latter have been described by Pappenheimer,[31] Dodds and Cameron,[16] and Park.[32] To my knowledge they are found in no other condition. This justifies at least the tentative suggestion that some of the mechanisms involved may be the same in both. Whereas Dahl[10] considers these prolongations after irradiation to be the result of cartilage proliferation toward the diaphysis I believe they are more satisfactorily explained on the basis of deficient chondroclasis incident upon vascular sclerosis and hypoplasia.

The amount and type of diaphyseal and metaphyseal new bone is indirectly modified by roentgen irradiation. It is directly influenced by the number, distribution and functional condition of the osteoblasts and the structural framework upon which they deposit osteoid. When, as a result of deficient chondroclasis and osteoclasis this framework is coarse, then the new-formed trabeculae are heavy, irregular and encompass remnants of chondrocytes and matrix. This interpretation differs from others who attribute the increased widths of trabeculae to overactivity of the osteoblasts.

Subnormal resorption of metaphyseal trabeculae was reported in rats after long continued injection of estradiol benzoate.[13] This produced a metaphyseal picture somewhat similar to the above, but chondroclasis was not disturbed. A dense thicket of metaphyseal matrix substance heavily impregnated with calcium and lead phosphate is found in lead poisoning, while after phosphorus ingestion an excess of metaphyseal bone is present.[21,33] These conditions in some ways simulate the post-irradiation changes described above, but there are important differences which prevent the advancement of even a common theory to account for all.

When osteoblasts are deficient or absent, no osteoid tissue is found about the periphery of the longitudinal metaphyseal spicules. Calcified material is laid down, however, usually in a transverse band in juxtaposition to the bases of the cartilage columns. Under such conditions cartilage cells having the morphology of hyaline cartilage appear to be directly converted into bone, but the major portion of the brittle, calcified material is almost completely acellular and avascular and should be considered as "pseudo bone." This zone is weak and prone to break.[22]

Cartilage cells possess amazing powers of regeneration. Even after doses of roentgen radiation producing fatty marrow fibrosis, cessation of growth in length, obliteration of end capillaries and dense impenetrable barriers of pseudo bone which presumably cut off communication and nutrition, young, actively growing cartilage cells are found in Zone 1. If a sufficiently long time is allowed to elapse the surviving cells regenerate and migrate distally to form a new functioning epiphyseal line.

In the interval after irradiation there is a very close correlation between blood vessel recovery or regeneration and return of various growth functions. When the vessels appear normal, the marrow cells and osteoblasts also appear normal. Under these conditions, too, chondroclasis and osteoclasis, new bone formation and growth in length all progress physiologically. The return to normal histology is much more prompt in young animals and in the portions of the cartilage plate closest to the periosteal vessels. In older animals receiving doses high enough to practically destroy the vessels and marrow cells, chondroclasis, bone resorption, columnar arrangement and true osteoblastic bone formation are absent or strikingly deficient several months subsequent to the irradiation.

CONCLUSIONS

Roentgen rays in sufficient quantities produce definite and characteristic microscopic changes in the epiphyseal cartilages of growing rats. The microscopic abnormalities become evident before there is appreciable interference with growth. Stunting, when it occurs, is apparently the result of temporary retardation or cessation of cartilage growth in a distal direction. This

is no doubt due to a direct effect upon the dividing cells, and produces a "line of growth arrest," such as has been described following acute disease in early childhood. Other more lasting secondary effects are explained on the basis of injury to vessels, osteoblasts and marrow cells.

The histopathological changes in every instance are dependent upon the interrelated factors of dose, age and interval after irradiation. At various intervals, governed by these factors, cartilage abnormalities result, which persist for variable lengths of time. Then follow regeneration and resumption of growth. The cartilage cells, which grow and migrate distally, tend to resume their normal relations with each other so that months later the abnormal appearance is lost.

After relatively low doses, particularly in young animals, histopathological changes appear promptly and are followed by almost complete subsequent return to normal microscopic morphology. In such cases growth proceeds in a physiological manner and at a rate approaching normal. After high doses in the older age groups, abnormalities appear later and last longer. Under these circumstances the quantities of roentgen rays required to inhibit growth also induce such marked changes in supporting tissues, bone marrow and blood vessels that if cartilage regeneration occurs it is incomplete and growth remains subnormal.

The amount of osteoclasis and chondroclasis, which occurs proximal to the advancing line of cartilage columns, and the degree of normal anatomical restitution are directly proportional to the completeness of marrow and vascular regeneration.

The processes of chondroclasis and osteoclasis are deficient when the marrow cells and vessels are seriously injured. As a result of this, cartilage cells persist as such far from the growth zone and become embodied in the newly formed bone, where they may be found months later.

Osteoid deposition and true osteogenesis do not appear to take place in the absence of osteoblasts. When osteoblasts are absent and cartilage growth has been resumed there is evidence that peculiar acellular brittle "pseudo bone" is formed. In some situations it appears that bone is formed from modified cartilage cells.

In all instances, there is augmentation of mineral deposition in the matrix substance soon after irradiation. The metaphyseal region of bones growing after irradiation contains more mineral and more bone than normal.

The growth impetus is so strong in the cartilage cells that even when they are abnormal in appearance, apparently imprisoned within sclerotic bony barriers and lying in a practically avascular environment, they grow toward the epiphysis. The power to regenerate is retained even after very large quantities of roentgen rays.

Blood vessels are markedly reduced in number and rendered irregular in caliber and distribution by doses seriously affecting the marrow cells in general. This is most marked following large doses in older animals. After smaller doses and in younger animals, they are less severely affected and regenerate much more rapidly and completely.

Normal cartilage cells are large in size and are arranged in orderly columns so that abnormalities are readily recognized. For these reasons growing mammalian epiphyseal cartilage appears to be an excellent biological medium for the study of roentgen-ray effects. Study of the modifications induced in cartilage growth, matrix mineralization, osteogenesis, chondro- and osteoclasis, and blood vessel invasion may contribute to an understanding of the dynamics and physiology of bone growth.

I wish to express my appreciation to Dr. Ross Golden, Dr. A. M. Pappenheimer and Dr. A. P. Stout for their guidance and assistance in carrying out this study.

REFERENCES

1. Barr, D. P. Pathological calcification. *Physiol. Rev.*, 1932, *12*, 593–624.
2. Baunach, A. Ueber den Einfluss von Dosis und Rhythmus auf den Grad der Wachstumsschädigung des Knochenwachstums bei Rönt-

genstrahlungen. *Strahlentherapie*, 1935, *54*, 52–67.

3. Bisgard, J. D., and Hunt, H. B. Influence of roentgen rays and radium on epiphyseal growth of long bones. *Radiology*, 1936, *26*, 56–64.
4. Brooks, B., and Hillstrom, H. T. Effect of roentgen rays on bone growth and regeneration; experimental study. *Am. J. Surg.*, 1933, *20*, 599–614.
5. Casati, A. Experimentelle Untersuchungen über die Röntgenwirkung auf das Knochenmark. *Strahlentherapie*, 1929, *32*, 721–738; 1930, *38*, 315–321; 1932, *43*, 582–588.
6. Clark, A. J. The Mode of Action of Drugs on Cells. Williams and Wilkins Co., Baltimore, 1933.
7. Dahl, B. Effets des rayons X sur les os longs en développement. *J. de radiol. et d'électrol.*, 1934, *18*, 131–140.
8. Dahl, B. La théorie de l'ostéoclasie et le comportement des ostéoclastes vis à vis du bleu Trypan et vis à vis de l'irradiation aux rayons X. *Acta path. et microbiol. Scandinav.*, Suppl., 1936, *26*, 234–239.
9. Dahl, B. Nouvelles recherches sur l'effet inhibiteur des rayons de Roentgen sur la formation de cal. *Acta radiol.*, 1937, *18*, 565–577.
10. Dahl, B. De l'effet des rayons X sur les os longs en développement et sur la formation de cal. Etude radiobiologique et anatomique chez le rat. Jacob Dybwad, 1936.
11. David, O. Examination of effect of roentgen rays on blood vessels and capillaries. *Brit. J. Radiol.*, 1925, *30*, 462–464.
12. Dawson, A. B. Histological study of persisting cartilage plates inr etarded or lapsed epiphyseal union in albino rat. *Anat. Rec.*, 1929, *43*, 109–123.
13. Day, H. G., and Follis, R. H., Jr. Skeletal changes in rats receiving estradiol benzoate as indicated by histological studies and determinations of bone ash; serum calcium and phosphatase. *Endocrinology*, 1941, *28*, 83–93.
14. Dodds, G. S. Row formation and other types of arrangement of cartilage cells in endochondral ossification. *Anat. Rec.*, 1930, *46*, 385–399.
15. Dodds, G. S. Osteoclasts and cartilage removal in endochondral ossification of certain mammals. *Am. J. Anat.*, 1932, *50*, 97–127.
16. Dodds, G. S., and Cameron, H. C. Studies on experimental rickets in rats. I. Structural modifications of epiphyseal cartilages in tibia and other bones. *Am. J. Anat.*, 1934, *55*, 135–165. Studies on experimental rickets in rats. II. Healing process in head of tibia and other bones. *Am. J. Path.*, 1938, *14*, 273–296. Studies on experimental rickets in rats. III. Behavior and fate of cartilage remnants in rachitic metaphysis. *Am. J. Path.*, 1939, *15*, 723–740.
17. Downing, V., Bishop, F. W., and Warren, S. L. Effects of roentgen irradiation upon blood vessels of repair tissue and the Brown-Pearce rabbit epithelioma. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 249–261.
18. Duggar, B. M., Editor. Biological Effects of Radiation. Vol. I. McGraw-Hill Book Co., New York, 1936.
19. Engel, D. Experimental study of action of radium on developing bones. *Brit. J. Radiol.*, 1938, *11*, 779–803.
20. Ewing, J. Radiation osteitis. *Acta radiol.*, 1926, *6*, 399–412.
21. Gall, E. A., Barr, J. S., and Lingley, J. R. Effect of elementary phosphorus upon epiphysis of albino rat. *Proc. Soc. Exper. Biol. & Med.*, 1940, *45*, 539–543.
22. Gall, E. A., Lingley, J. R., and Hilcken, J. A. Comparative experimental studies of 200 kilovolt and 1000 kilovolt roentgen rays. I. Biological effects on epiphysis of albino rat. *Am. J. Path.*, 1940, *16*, 605–618.
23. Harris, H. A., Lines of arrested growth in the long bones in childhood; correlation of histological and radiographic appearances in clinical and experimental conditions. *Brit. J. Radiol.*, 1931, *4*, 561–588.
24. Hinkel, C. L. Effect of roentgen rays upon the growing long bones of albino rats. I. Quantitative studies of the growth limitation following irradiation. Am. J. Roentgenol. & Rad. Therapy, 1942, *47*, 439–457.
25. Hoffman, V. Ueber Erregung und Lähmung tierischer Zellen durch Röntgenstrahlen. *Strahlentherapie*, 1922, *13*, 285; 1923, *14*, 516.
26. Kleinmann, H. Untersuchungen über die Bedingungen der Kalkablagerung in tierischen Geweben. *Virchow's Arch. f. path. Anat.*, 1928, *268*, 686–750.
27. Lingley, J. R., Gall, E. A., and Hilcken, J. A. Comparative experimental studies of 200 kilovolt and 1000 kilovolt roentgen rays. II. Biological effects on the bone marrow of the albino rat. *Am. J. Path.*, 1940, *16*, 845–854.
28. Montgomery, H. Pathologic Histology of Radiodermatitis. Chapter 24. In: MacKee, G. M. X-Rays and Radium in the Treatment of Diseases of the Skin. Third edition, Lea & Febiger, Philadelphia, 1938.
29. Mottram, J. C. Histological changes in bone marrow of rats exposed to irradiation from radium. *Arch. Radiol. & Electrother.*, 1920, *25*, 197.
30. Murray, C. R. Modern conception of bone formation and its relation to surgery. *J. Dent. Research*, 1931, *11*, 837.
31. Pappenheimer, A. M. Anatomical changes which accompany the healing of experimental rat rickets under the influence of cod liver oil

or its active derivatives. *J. Exper. Med.*, 1922, *36*, 335–356.

32. Park, E. A. Observations on the pathology of rickets with particular reference to changes at the cartilage-shaft junctions of the growing bones. The Harvey Lectures, 1938–1939, 157–213.
33. Park, E. A., Jackson, D., Goodwin, T. C., and Kajdi, L. X-ray shadows in growing bones produced by lead; their characteristics, cause, anatomical counterpart in bone and differentiation. *J. Pediat.*, 1933, *3*, 265–298.
34. Perthes, G. Ueber den Einfluss der Röntgenstrahlen auf epithelial Gewebe insbesondere auf das Carcinom. *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1903, *32*, 525.
35. Phemister, D. B. Radium necrosis of bone. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 340–348.
36. Recamier, D., and Tribondeau, L. A propos de l'action des rayons X sur l'ostéogenese. *Compt. rend. Soc. de biol.*, 1905, *59*, 621.
37. Rous, P. Relative reaction within living mammalian tissues; general features of vital staining with litmus. *J. Exper. Med.*, 1925, *41*, 379–397.
38. Salvetti, E. Einfluss der Röntgenstrahlen auf die Bildung der Knochennarbe. *Deutsche Ztschr. f. Chir.*, 1914, *28*, 130.
39. Segale, G. C. Sull'azione biologica dei raggi Röntgen e del radium sulle cartilagini epifisarie. *Radiol. med.*, 1920, *7*, 234–246.
40. Shipley, P. G., and Macklin, C. C. Some features of osteogenesis in light of vital staining. *Am. J. Physiol.*, 1916, *42*, 117.
41. Siciliano, L., and Buonamici, C. B. Studi sul midollo osseo sotto l'azione dei raggi X. *Arch. di radiol.*, 1930, *6*, 1108–1136.
42. Stout, A. P. Some changes occurring in accidentally transplanted bone. *Proc. New York Path. Soc.*, 1923, *23*, 121.
43. Stump, C. W. Histogenesis of bone. *J. Anat.*, 1924, *59*, 136.
44. Warren, S. L. Physiological Effects of Radiation upon Organ and Body Systems. In: Biological Effects of Radiation, Duggar, B. M., Editor. Vol. 1, Chap. 14, p. 473. McGraw-Hill Book Co. New York, 1936.

Vol. 49, No. 3

CONTRIBUTIONS OF ROENTGENOLOGY TO THE DIAGNOSIS OF CHRONIC CONSTRICTIVE PERICARDITIS*

By HAROLD J. STEWART, JOHN R. CARTY, *and* JOHN R. SEAL
NEW YORK, NEW YORK

THE interest which has been aroused in this country by the demonstration that surgical removal of the pericardium offers relief to the majority of patients suffering from chronic constrictive pericarditis has led to the recognition of increasingly large numbers of patients with this disease. The literature during the past decade has contained numerous reports on the clinical features, pathologic physiology and surgical technique which have greatly increased our knowledge of its various aspects and contributed towards its recognition. This recognition in many cases is not too difficult, especially when the triad which Beck[3,4] has pointed out, namely, "The small quiet heart, high venous pressure, ascites and hepatomegaly," are present. In many cases where the size of the heart is above the normal limits, or in the occasional case with coexistent disease of the cardiovascular system of other nature, the diagnosis is more difficult and usually the burden of differential diagnosis falls to large measure on the roentgenologist. As only a few radiologists have had opportunity to study a sufficient number of these cases to allow comparative studies, the roentgenological literature is not large and further additions to it appear warranted.

White,[32] in a comprehensive review of the literature prior to 1935, attributes the original description of chronic constrictive pericarditis to Lower in 1669 and the first antemortem diagnosis to Kussmaul in 1873. Pick,[19] in 1896, reported in detail on 3 cases and gained the first widespread recognition for the disease to which his name is often applied. In 1898, Delorme[9] insisted from a study on cadavers that surgical removal of the pericardium would one day bring relief to those suffering from the disease, but it was not until 1913 that Rehn[20] and Sauerbruch[22] independently and successfully performed this operation. Schmieden[23,24,25] and associates, beginning in 1917, have reported on 22 cases in which the operation has been performed. Schmieden and Volhard[23] in 1923, discussed the diagnosis and pathologic physiology, applying the phrase "inflow stasis" to the primary defect in the circulation. This work was later amplified by Schmieden and Fischer,[24] who included a summary of the roentgenological observations in 8 cases, pointing out that the cardiac silhouette may be enlarged by the thickened pericardium itself, that there may or may not be calcification of the pericardium, and that the latter condition need not be associated with constriction of the heart.

In 1929, Churchill[8] reported the first successful operation for removal of the pericardium in chronic constrictive pericarditis to be carried out in this country. Beck and Griswold[1] reported similar success the following year. These reports initiated the interest which has been manifest in this disease since that time. The etiology in the majority of cases remains unknown but tuberculosis undoubtedly plays a large rôle,[5,7,16] as does pneumonia and empyema.[7] The clinical and pathological aspects have been well established largely through the work of Beck,[1,2,3,4] White,[31,32] Blalock,[5,7] Burwell[6,7] and their associates, and Stewart and Heuer.[14,29,30] They point out the long standing venous engorgement, dyspnea, ascites with hepatomegaly, weakness, and sometimes edema, which characterize the clinical picture and most of them stress the "small,

* From the Departments of Medicine and Radiology of the New York Hospital and Cornell University Medical College, New York. Presented at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

quiet heart" as an outstanding feature. Beck[4] has also pointed out the confusing terminology and descriptions in the literature and texts dealing with diseases of the pericardium which have been brought about through the concept that adhesions between the heart and neighboring structures may produce dilatation, hypertrophy, and failure of the heart. Experimental and anatomical studies have failed to support this concept and it is his opinion that constriction of the heart is the only means by which pericardial disease can cause disturbance of the heart or circulation. Sprague[28] pointed out the frequency with which a completely adherent pericardium is an unimportant finding (2.26 per cent of the cases in a series of 1,900 autopsies at the Massachusetts General Hospital) and others have made similar observations in reference to both adhesions and calcium deposits.[17,27] Burwell and Flickinger,[6] Beck and Cox,[2] and more extensively, Stewart and Heuer,[29,30] have studied the abnormal circulation which results from compression of the heart and interference with its diastolic filling. The latter authors were able to study 9 cases before and after operation; they found that before operation the arteriovenous oxygen difference was increased, the minute output of the heart, the cardiac index, and the stroke volume were decreased, the venous pressure elevated, and the circulation time prolonged. After operation these measurements approached or attained normal levels. Schmieden and associates,[23,24,25] Churchill,[8] and White and Churchill,[31] Burwell and Blalock,[5,6,7] Beck[1,2,3,4] and Heuer and Stewart[14] have reviewed the surgical aspects of the disease in detail. In 1937, Heuer and Stewart[14] were able to collect 150 surgically treated cases (including 7 of their own) from the literature. Thirty-five per cent of these were reported as cured, 18.6 per cent as improved, and in only 1.3 per cent was there no improvement.

The more important studies in the roentgenologic aspects of the disease have been made in the last six years. White,[32] reporting 15 cases of chronic constrictive pericarditis, summarized the roentgenologic features as follows:

> The heart was normal in size in 7 and slightly to moderately enlarged in the remainder. The shape varied greatly from normal to so-called mitral configuration with prominence of the left upper border, and in 3 cases there was indication of left auricular enlargement (two of these had auricular fibrillation). The amount of pulsation varied widely from fairly free on both sides to little or none anywhere. It was quite a common observation to observe free pulsations of the cardiac apex and left border with no pulsation at the right border (which would extend a little too far to the right with a hazy outline). In most cases there was an increase in the supracardiac shadow, apparently due to dilatation of the superior vena cava and to mediastinal involvement or displacement. The lung hilar shadows were increased in 9 of these cases. In 6 a clue was presented by the finding of considerable pleural thickening. The heart itself was more or less anchored in six cases with or without restricted movements of the diaphragm on one side or the other. Pericardial calcification was noted on x-ray in 6 of the 15 cases but before operation in only 3 of the 12 cases that were operated upon. The presence of calcification is a helpful confirmatory sign but it is usually absent and when present it does not mean Pick's disease if there are no other evidences.

Johnson[15] was first to observe that the roentgen kymogram was of value in confirming the diagnosis of a case of chronic constrictive pericarditis, and Griswold[12] with a similar experience suggested that by measuring the increase in pulsations the technique might be of value in estimating the effectiveness of the surgery. Scott and Moore[26] also found the same characteristic diminution of pulsations in a case of active tuberculous pericarditis.

Roesler,[21] analyzing the literature and from his own experience comprehensively discussing the various roentgenologic features of chronic constrictive pericarditis, points out the various anatomical changes which underlie the changes seen in the roentgenogram and the factors which influence the signs obtained by roentgenos-

copy and kymography. Attention is called to the observation that while in most instances there is a diminished amplitude of pulsation, in others pulsations of normal amplitude or of greater than normal amplitude are present. In this latter group of cases there is no increased amplitude over the great vessels but rather a striking diminution, and measurements have shown that the cardiac output is diminished despite the apparent amplitude of contraction. This phenomenon is attributed to an altered manner of contraction in that the longitudinal contraction of the ventricular cone is interfered with by adhesions and this reduction of movement is compensated for by increased marginal contractions. These increased pulsations are most often observed over the left lower border where the pericardial scar is usually thinnest. It is also pointed out that the commonly sought signs of shifting of the anatomical axis of the heart with respiration and change in position are of diminished value in those cases with large hearts or where there are diminished excursions of the diaphragm.

Freedman,[10,11] in studies of 26 cases of chronic constrictive pericarditis, divided the roentgenologic signs into those based on the effect of the pericardial scar on configuration, size, and pulsation of the heart; those caused by adhesions between the heart and neighboring organs; and to those related to calcium deposits. In 16 of these cases the heart size was normal or slightly smaller than normal, in 8 it was moderately enlarged, and in 2 greatly enlarged. One of the last group at autopsy had a pericardium varying from 2 to 26 mm. in thickness, and in none of the 6 cases who came to autopsy was the heart weight above normal. The configuration in 13 cases was triangular, in 8 globular, and in 5 was either of the mitral or aortic type. Normal subdivision of the left or right aortic arch was almost always absent and obliteration or marked flattening of the aortic knob was the most constant sign, being present in 21 cases. Other important findings were unchanging contour of the heart on respiratory movements and diminution or absence of pulsations, although there were occasionally pulsations of normal or increased amplitude over certain portions of the heart. Extrapericardial adhesions were demonstrated best by roentgenoscopy and it was believed that the most satisfactory sign of all was fixation of the heart in the midline during respiratory movements with the patient in the lateral recumbent position. At times adhesions between the pericardium and sternum were demonstrable in lateral roentgenograms, and in most cases there was increased density of the mediastinum interpreted as indicating chronic inflammation and fibrosis. Kymographic examination was felt to hold no specific diagnostic value but was used rather for an objective record of pulsations to which postoperative improvement in pulsation could be compared. The lung fields were normal in 5 cases, 16 had pleural effusion, 9 had evidence of chronic passive congestion, 3 had chronic pulmonary tuberculosis, and in 1 there was silicosis. The contour of the diaphragms was normal in only 6 cases, in the others it was either obscured by effusion or was irregular and flattened by adhesions. Calcium deposits were demonstrated in 9 of the 26 cases. Postoperatively, marked changes were never found. In some, the heart size was larger and in all, the pulsations were increased over part or all of the circumference. In conclusion, the author states, "the most conclusive sign of cardiac compression is calcification which is present in only a minority of the cases. When calcification is absent several of the more important signs must be combined to arrive at an accurate diagnosis and in any case the careful correlation of clinical and roentgenological evidence is necessary. The heart is usually normal or smaller than normal, never large enough to confuse with the large shadow seen in the roentgenogram of the dilated, failing heart. When slight to moderate enlargement is present it is usually due to the thickness of the peri-

TABLE I.—SUMMARY OF THE MAIN CLINICAL AND LABORATORY

Case and History No.	Age and Sex	Duration	History of Rheumatic Infection	History of Tuberculous Infection	History of Nonspecific Pulmonary Infection Just Prior to Onset	History of Pericarditis or Pericardial Effusion	Chief Symptoms	Evidence of Valvular Disease	Dyspnea	Cyanosis	Distended Cervical Veins	Rales	Pleural Effusion	Enlarged Liver	Ascites	Edema	Paradoxical Pulse
Case I A.R. #91648	29 F	¼ yr.	o	o	o	o	Dyspnea, weakness, swelling of abdomen	o	+	+	+	+	+	+	+	+	+
Case II W.M. #103699	36 M	2⅔ yr.	o	o	+	o	Dyspnea, edema, precordial discomfort	o	+	+	+	o	o	o	o	+	+
Case III C.G. #97484	29 M	9 yr.	o	o	+	o	Epigastric discomfort and swelling on exertion	o	±	+	+	o	+	+	o	o	+
Case IV J.P. #155618	36 M	8+yr.	o	o	o	o	Dyspnea, swelling of abdomen, edema	o	+	+	+	+	+	+	+	+	+
Case V A.B. #28323	15 F	5½ yr.	+	+	o	o	Dyspnea, swelling of abdomen, weight loss	o	o	+	+	o	o	+	o	o	+
Case VI P.A. #141257	44 F	⅙ yr.	+	o	o	o	Swelling of abdomen, edema	o	o	+	+	±	+	+	+	+	+
Case VII J.McC. #128763	20 M	1¼ yr.	o	o	o	+	Dyspnea, swelling of abdomen	o	±	±	+	+	+	+	o	o	+
Case VIII J.S. #169168	38 F	6 yr.	o	o	+	o	Swelling of abdomen, edema	o	+	+	+	±	+	±	+	+	+
Case IX R.S. #185223	58 M	6 yr.	o	o	o	o	Dyspnea, edema	o	o	+	+	+	o	+	+	+	+
Case X G.S. #232001	52 M	7+ yr.	?	?	+	?	Swelling of abdomen	o	o	+	+	+	o	+	+	o	+
Case XI E.B. #233623	22 M	1⅔ yr.	o	o	+	o	Dyspnea, edema	o	+	+	+	+	+	+	o	+	+
Case XII P.M. #273718	42 M	8 yr.	?	o	+	?	Edema, dyspnea	o	+	+	+	+	+	+	+	+	+
Case XIII F.B. #268178	50 M	?15 yr.	o	o	+	?	Edema, dyspnea	o	+	+	+	+	+	±	±	+	+
Case XIV W.H. #272368	46 M	6 yr.	o	o	o	+	Swelling of abdomen, edema	o	+	+	+	+	+	+	±	+	+
Case XV F.H. #290924	17 M	1 yr.	o	o	o	o	Dyspnea, swelling of abdomen	?	+	+	+	o	o	+	+	o	+
Case XVI J.C. #290121	7 M	⅙ yr.	o	o	o	o	Dyspnea, swelling of abdomen	?	+	+	+	o	+	+	+	+	+

* N.S.R. = normal sinus rhythm.
A.F = auricular fibrillation.
In this table as well as in Table II o = absent, + = present, ? = questionable, ± = borderline, and − = observations not made or could not be determined.

cardium, to underlying valvular disease or other cause of hypertrophy of the heart. . . ." A recent report by Harrington and Barnes[13] is of interest from the roentgenologic standpoint because of the unusually high percentage of 6 out of 9 cases in which calcium in the pericardium was found in roentgenograms.

SUMMARY OF CASES NOW BEING REPORTED TOGETHER WITH THE CLINICAL CHACTERISTICS

Since 1935, 16 cases of chronic constrictive pericarditis have been seen at the New York Hospital; 14 of these had pericardiectomy performed at this Hospital and 2 came to operation elsewhere (Beck and

FEATURES IN CHRONIC CONSTRICTIVE PERICARDITIS

Blood Pressure	Clinical Size of Heart	Electrocardiographic Characteristics					Circulation Time	Venous Pressure	Cardiac Output	Cardiac Index	Length of Post-operative Observation	Clinical Result
		Rhythm*	Axis Deviation	QRS Complexes Leads I, II and III	T Waves Leads I, II and III	Shift of Electrical Axis						
112/74	Normal	N.S.R.	Slight right	Low amplitude	Low amplitude	11°	Increased	Increased	Decreased	Decreased	5 yr.	Cure
115/70	Normal	N.S.R.	Right	Low amplitude	I and III negative	0°	Increased	Increased	Decreased	Decreased	5 yr.	Cure
100/80	Moderately enlarged	N.S.R.	Slight right	Low amplitude	II and III negative, cove shaped	0°	Increased	Increased	Decreased	Decreased	1 yr.	Death from pulmonary emboli
100/68	Normal	A.F.	None	Low amplitude	Low amplitude, diphasic	5°	Increased	Increased	—	—	½ yr.	Death from bronchopneumonia
88/52	Normal	N.S.R.	Slight right	Low amplitude	Low amplitude, II and III cove shaped	37°	Increased	Increased	Decreased	Decreased	Cure Died 3 yr. after operation of tuberculous peritonitis	
110/70	Moderately enlarged	A.F.	None	Low amplitude	Low amplitude, diphasic	35°	Increased	Increased	Decreased	Decreased	4½ yr.	Marked improvement
106/80	Normal	N.S.R.	Slight left	Low amplitude	I and II cove shaped	11°	Increased	Increased	Decreased	Decreased	4 yr.	Marked improvement
130/78	Normal	N.S.R.	Slight left	Low amplitude	III low amplitude	0°	Normal	Increased	Normal	Normal	4 yr.	Slight improvement
155/100	Moderately enlarged	A.F.	Right	Low amplitude	I and III low amplitude, diphasic	26°	Increased	Increased	Decreased	Decreased	3 yr.	Moderate improvement
92/64	Normal	A.F.	None	I low amplitude	I low amplitude, II and III negative	43°	Increased	Increased	—	—	2 yr.	Moderate improvement
100/80	Slightly enlarged	N.S.R.	None	Low amplitude	Low amplitude, III cove shaped	12°	Normal	Increased	—	—	2¼ yr.	Marked improvement
104/60	Slightly enlarged	A.F.	None	Low amplitude	Diphasic	21°	Increased	Increased	—	—	⅔ yr.	Moderate improvement
195/150 to 136/94	Normal	N.S.R.	Slight right	Normal	Diphasic, II and III cove shaped	11°	Increased	Increased	—	—	—	Died June, 1941
105/80	Moderately enlarged	A.F.	None	Low amplitude	Diphasic, low amplitude	29°	Increased	Increased	—	—	—	Death on operating table
110/64	Slightly enlarged	N.S.R.	Right	I low amplitude	II diphasic, III negative	17°	Normal	Increased	—	—	⅙ yr.	Marked improvement
85/65	Slightly enlarged	N.S.R.	None	Low amplitude	II and III cove shaped	13°	Increased	Increased	—	—	⅙ yr.	Improved

Thompson). Twelve cases were operated upon by Dr. George J. Heuer, 2 cases were operated upon by Dr. William DeW. Andrus, 1 case was operated upon by Dr. Claude S. Beck and 1 case was operated upon by Dr. Samuel A. Thompson. In all a thickened, adherent, and constricting pericardium was found. Eleven remain under observation at the present time. The youngest was seven and the oldest case was fifty-eight years of age; the highest incidence fell in the third decade, and 3 cases over fifty years of age are included in the series. Twelve were males and only 4 females. The duration as estimated from the history varied from two and one-half months to fifteen years. In 2 only was there history suggestive of rheumatic fever, and in 1 only was there a history of definite tuberculous infection. Seven gave a clear

TABLE II.—SUMMARY OF THE MAJOR ROENTGENOLOGICAL

Case No.	ROENTGENOSCOPY			PREOPERATIVE ROENTGENOGRAMS											
	Limitation of Shift of Heart on Change of Position or Inspiration	Motion Diaphragms	Pulsations	Estimated Size	Shape	Adhesions	Calcification	Aortic Knob	Superior Mediastinum	Mediastinum	Dorsal Vertebra	Increased Vascular Markings	Evidence of Tuberculosis	Evidence of Chronic Infection	Effusion
Case I A.R.	Marked	Normal	Decreased generally	Moderately enlarged	Triangular	+	o	Absent	Normal	Clear	Slight kyphosis	++++	o	o	Left
Case II W.M.	Moderate	Both limited	Decreased generally	Moderately enlarged	Globular	+	o	Small	Normal	Clear	Slight kyphosis	++	Hilar calcification	o	Left
Case III C.G.	•	Normal	Marked general decrease	Slightly enlarged	Globular	o	+	Small	Slightly widened	Clear	Slight kyphosis, arthritis	+++	Hilar calcification	o	Right
Case IV J.P.	Marked	Paradoxical motion in right	Marked decrease except at apex	Moderately enlarged	Triangular	o	o	Slightly enlarged	Marked widening	—	—	+++	o	o	Right
Case V* A.B.	Marked	Both limited	Marked general decrease	Slightly small	Globular	o	+	Absent	Normal	Clear	Normal	+++	o	o	None
Case VI P.A.	Moderate	Right limited	Marked decrease except at apex	Slightly small	Globular	o	+	Absent	Normal	Clear	Slight kyphosis, arthritis	+++	Hilar calcification	o	Right
Case VII† W.McC.	Marked	Normal	Marked general decrease	Moderately enlarged	Globular	o	o	Absent	Normal	Clear	Normal	+++	o	o	Right
Case VIII J.S.	Moderate	Normal	Marked decrease except at apex	Slightly enlarged	Triangular	o	o	Small	Slightly widened	Clear	Normal	+++	Hilar calcification	o	None
Case IX R.S.	None	Normal	Decreased on right	Markedly enlarged	Boot shaped	o	+	Dilated and elongated	Slightly widened	Clear	Arthritis	+++	o	o	None
Case X G.S.	—	Both limited	Decreased except at apex	Slightly small	Globular	o	+	Absent	Slightly widened	Clear	Normal	+	o	o	Right
Case XI E.B.	—	Normal	Marked decrease	Slightly enlarged	Triangular	o	o	Small	Moderately widened	Obscured	Normal	+++	o	++	Left
Case XII P.M.§	Moderate	Both limited	Decreased on right	Moderately enlarged	Globular	+	+	Small	Normal	Obscured	Moderate kyphosis, arthritis	+++	o	o	Right and left
Case XIII‡ F.B.	—	—	Marked general decrease	Moderately enlarged	Globular	o	o	Small	Slightly widened	Obscured	—	+++	o	o	Right
Case XIV# W.F.	None	Normal	Marked general decrease	Markedly enlarged	Triangular	+	o	Small	Markedly widened	—	Normal	+++	o	o	Right
Case XV§ F.H.	Marked	Normal	Decreased except at pulmonary conus	Slightly enlarged	Globular	o	+	Small	Normal	Clear	Normal	+++	o	o	None
Case XVI J.C.	Marked	Normal	Decreased except at pulmonary conus	Moderately enlarged	Triangular	o	o	Small	Normal	Clear	Normal	++	o	o	Left

* Died 3 years later of tuberculous and purulent peritonitis.
† Small foci of active inflammation present microscopically.
‡ Pericardiectomy was performed in this case by Dr. C. S. Beck in Cleveland, Ohio, to whom we are indebted for data concerning operation and subsequent course.
Pericardiectomy was performed in this case by Dr. Thompson of Flower Fifth Avenue Hospital, and we are indebted to Dr. Milton J. Raisbeck for details of the operation and autopsy.
§ Cases No. XII and XV were operated upon by Dr. William DeW. Andrus. The others were operated upon by Dr. George J. Heuer.

history of nonspecific pulmonary infection preceding the onset of symptoms, and in a few increased severity of symptoms was noted during subsequent nonspecific respiratory infections. In 2 cases there was a definite history of pericardial effusion and in 3 others a suggestive history. Dyspnea was the most common symptom, being a presenting complaint in 13 of the 16 cases. Ten had experienced enlargement of the abdomen and in 9 a noticeable degree of edema of the lower extremities had been present. The most uniform physical findings were paradoxical pulse, cyanosis, dis-

OBSERVATIONS IN CHRONIC CONSTRICTIVE PERICARDITIS

ROENTGEN KYMOGRAMS				OPERATIVE AND PATHOLOGIC FINDINGS					POSTOPERATIVE ROENTGEN STUDIES				
Pulsations of Right Cardiac Border	Pulsations of Left Ventricle	Pulsations of Pulmonary Conus	Pulsations of Aorta	Pericardium Thickened and Adherent	Gross Calcification	Microscopic Calcification	Active Tuberculosis	Thickness	Size	Contour	Aorta	Lung Fields	Pulsations
—	—	—	—	+	o	o	+	3–4 mm.	Normal	Normal	Normal	Normal	Normal
—	—	—	—	+	o	+	o	2 mm.	Smaller	More normal	More normal	More normal	Improved over left ventricle
Marked decrease	Slight decrease	Slight decrease	Slight decrease	+	+	+	o	2–3 mm.	Larger	Changed	Same	Same	Slight increase
Absent	Marked decrease except at apex	Decreased	Decreased	+	o	+	o	1–4 mm.		All Portable Roentgenograms			
—	—	—	—	+	+	+	o	2–3 mm.	Normal	More normal	Same	More normal	Improved over left ventricle
—	—	—	—	+	+	+	o	5–8 mm.	Larger	Same	Same	More normal	Improved over left ventricle
—	—	—	—	+	o	o	o	5 mm.	Smaller	More normal	Same	Same	Improved over left ventricle
—	—	—	—	+	o	+	o	3 mm.	Larger	More normal	Same	More normal	Improved except over apex
Absent	Normal	Normal	Normal	+	+	+	o	1–4 mm.	Larger	Same	Same	Same	Slight increase on right
Moderate decrease	Marked decrease	Marked decrease	Marked decrease	+	+	+	o	1–2 mm.	Larger	Same	Same	Same	Increased on left
Absent	Marked decrease	Marked decrease	Marked decrease	+	+	+	o	5 mm.	Larger	Same	Same	Same	Slight general increase
Marked decrease	Moderate decrease	Marked decrease	Marked decrease	+	+	+	o	3–10 mm.	Same	More normal	More normal	More normal	Moderate general increase
Marked decrease	Marked decrease	Marked decrease	Marked decrease	+	o	o	o	Unknown	—	—	—	—	—
Marked decrease	Marked decrease	Increased	Decreased	+	o	o	o	2–4 mm.	—	—	—	—	—
Decreased	Decreased	Increased	Decreased	+	+	+	o	1–2 mm.	Slightly smaller	Same	Same	More normal	Moderate increase except on right
Decreased	Decreased	Increased	Decreased	+	+	+	o	2–3 mm.	Larger	Same	Same	Same	Moderate increase on left

tention of the cervical veins and increased venous pressure. Four had no dyspnea when seen, in 5 there were no pulmonary signs; and a quite striking disproportion between the degree of signs of heart failure and the severity of orthopnea was commonly observed. Hepatomegaly was questionable in 1 case and in 5 ascites was not demonstrable. Edema of the legs of a variable degree was present in 11 cases. The blood pressure was below 100/70 in 5 cases and in only 2 cases was it above 140/90; the pulse pressure ranged from 20 to 40 mm. Hg in 12 of the 16 cases. In 6 patients the rhythm was auricular fibrillation and in the other 10 normal sinus rhythm was present. The more common electrocardiographic abnormalities were often a tendency to slight axis deviation (6 to the right, 1 to the left and 9 no deviation), low ampli-

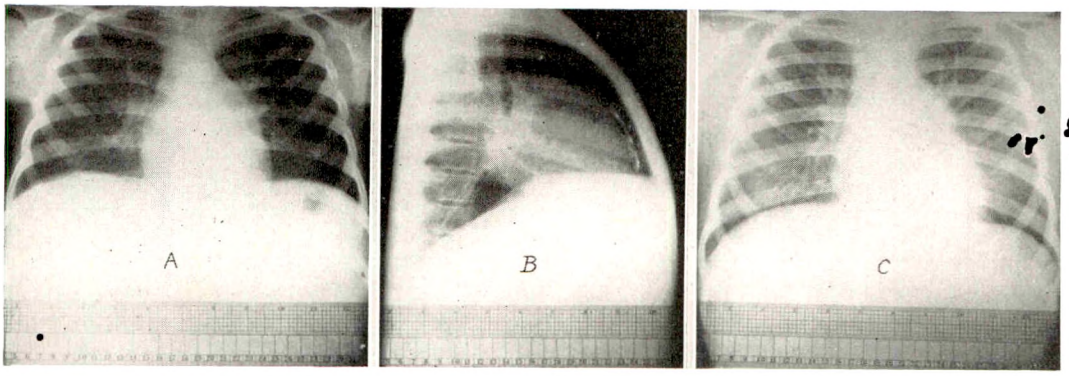


FIG. 1. Case V. *A* and *B*, taken on June 2, 1936, show the wide thoracic cage, the heart of slightly smaller size than normal and its globular shape. Calcification is visualized only in the lateral view. The aortic knob is small. *C*, taken on April 6, 1937, ten months after operation, shows an increase in the size of the cardiac silhouette with a pronounced bulge in the region of the pulmonary conus and widening of the superior mediastinum. Pericardiectomy effected a clinical cure.

tude of the QRS complexes, T waves of low amplitude which were usually diphasic or negative and often cove shaped in leads II and III. There was marked limitation in the shift of the electrical axis on change in position of the body in 10 patients. The operative technique and experiences in this group are similar to those previously reported[14] and the results are summarized in Tables I and II. The etiology in 1 case was found to be active tuberculous infection of the pericardium, in the others pathologic studies did not establish the cause.

ROENTGENOLOGIC OBSERVATIONS

All the roentgenologic observations were made by standard technique and one of the authors* was present with the roentgenol-

* H.J.S.

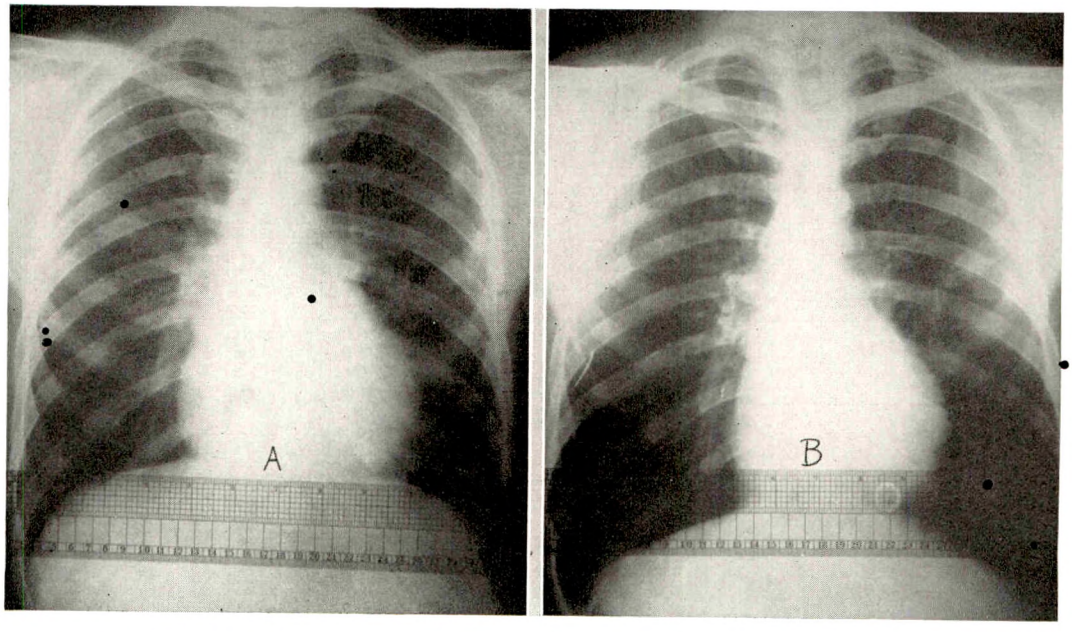


FIG. 2. Case II. *A*, taken on November 11, 1936, illustrates the globular shape of the heart, with obscuration of the normal subdivisions, moderate enlargement, and poorly defined aortic knob. In *B*, taken on April 1, 1937, five months after operation, there is decrease in size of the cardiac silhouette with more normal configuration, and increased prominence of the aortic knob.

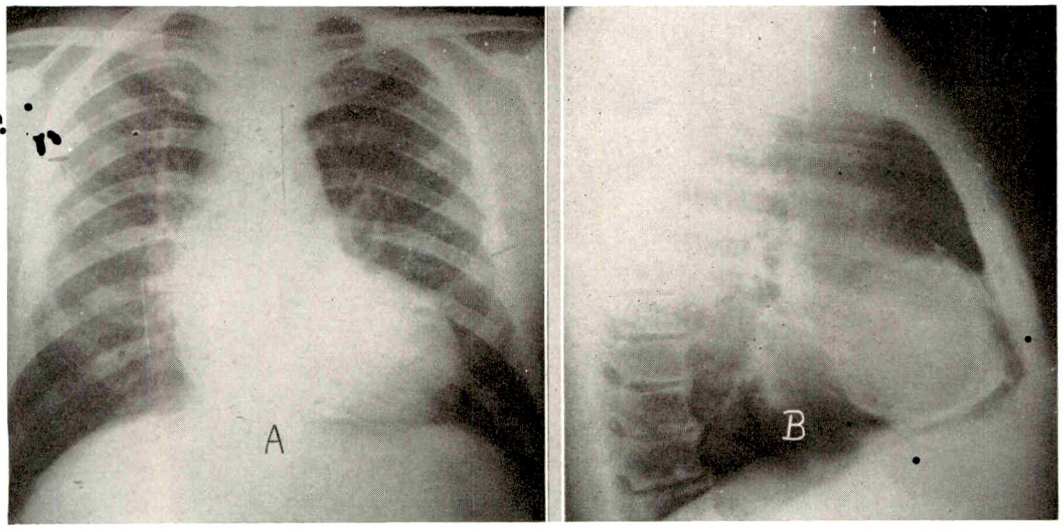


Fig. 3. Case ix. These preoperative roentgenograms illustrate the large boot-shaped heart with unusual configuration of the right border, *A*. Slight calcification is visible in the posteroanterior view, *A*, in contrast with the extensive calcification seen in the lateral view, *B*.

ogists when the roentgenoscopic studies were done in all cases. No special techniques were resorted to beyond that of inclining the patient from side to side in seeking shifting of the anatomical axis of the heart, and of heavier exposures in certain ones in an attempt to demonstrate calcification when it was not observed in the usual exposures. The chief abnormalities noted in roentgenologic studies are correlated in Table ii with age, duration, etiology, findings at operation, and result of pericardiectomy. The postoperative roentgenologic changes are also included.

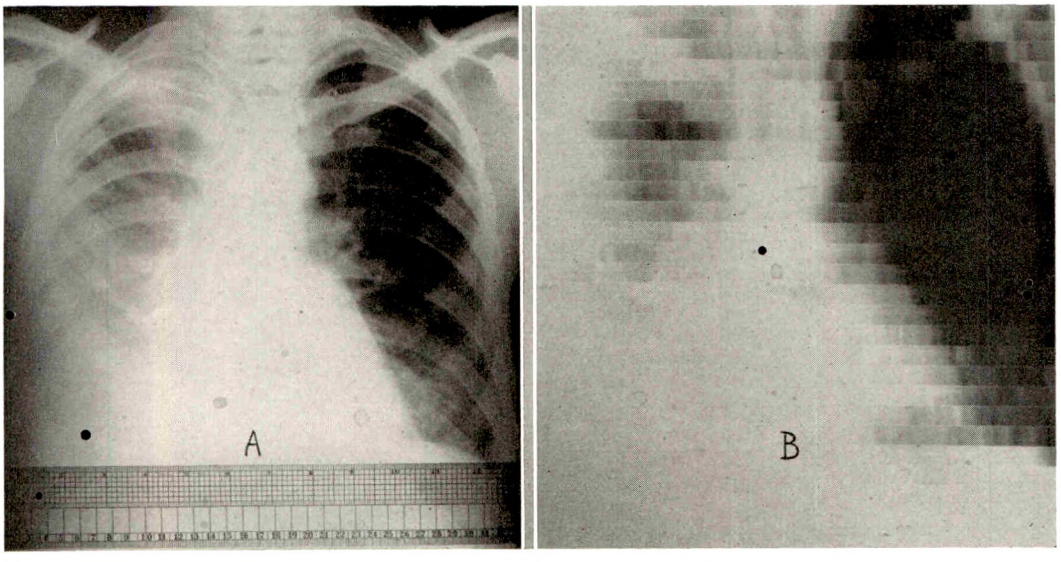
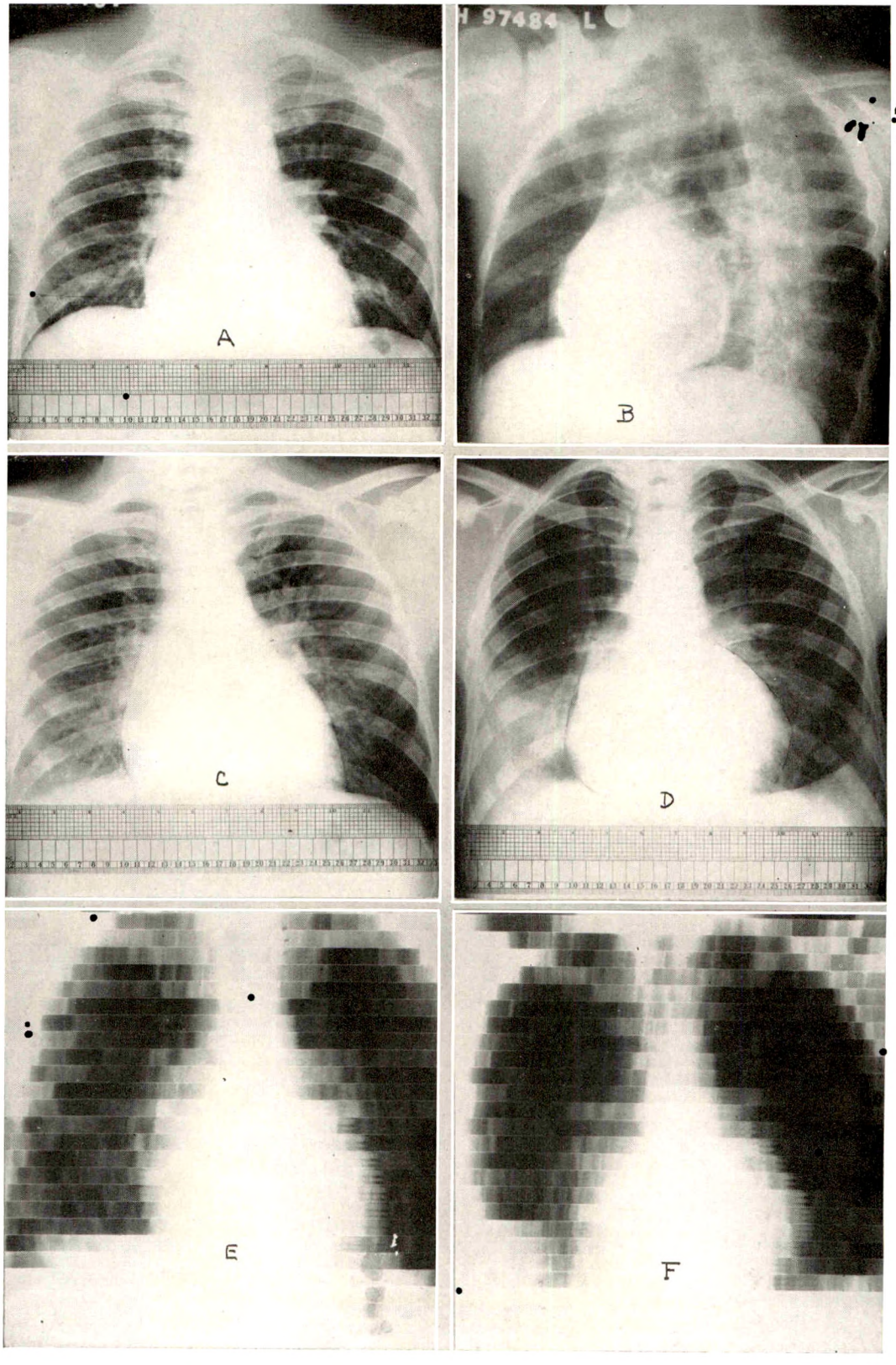


Fig. 4. Case xiv. These roentgenograms illustrate the enlarged triangular heart, marked pulmonary congestion, and absent aortic knob, *A*. The kymogram, *B*, reveals reduced amplitude of pulsation over all of the cardiac silhouette and aorta with the exception of the upper portion of the left ventricle where the pulsations are of normal amplitude.


H 97484 L
A
B
C
D
E
F

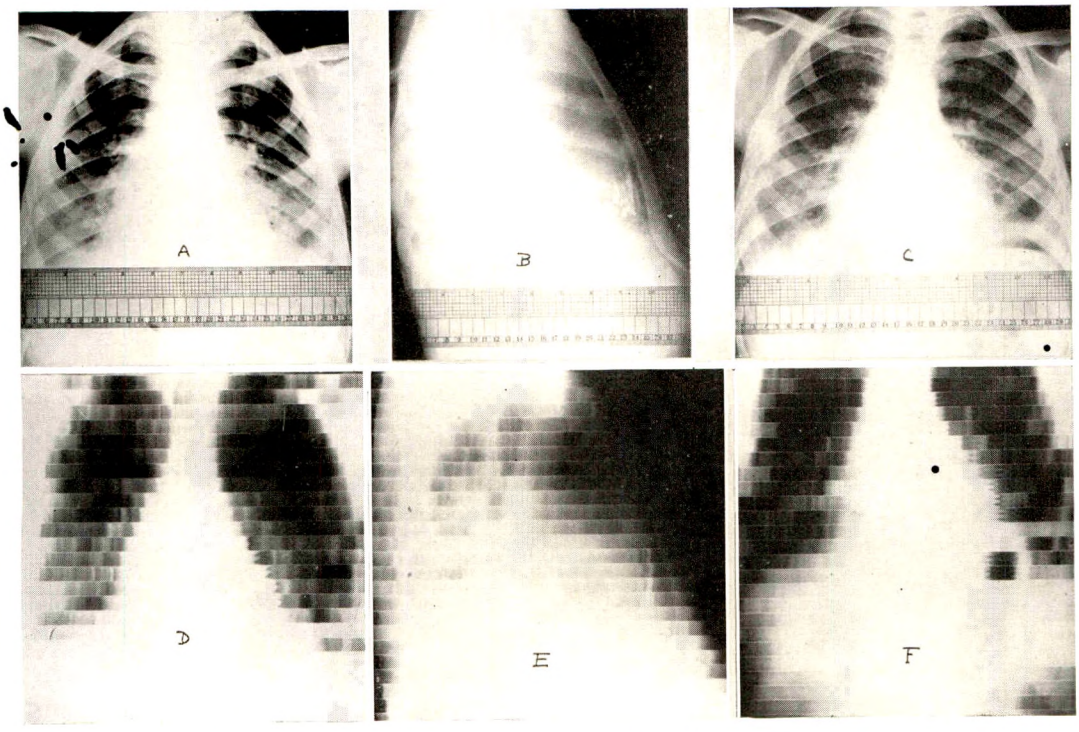


FIG. 6. Case XII. *A*, taken on September 11, 1940, illustrates the enlarged globular heart with obscuration of normal subdivisions of the borders and marked increase in the pulmonary vascular shadows. *B* records calcification seen only in the lateral view. *C*, taken on October 18, 1940, one month after operation, shows enlargement of the cardiac silhouette, a more prominent aortic knob, and decrease in the pulmonary congestion. *D*, a preoperative kymogram, shows marked decrease in pulsations over the right border, aorta, and upper left border. Pulsations at the apex, although good, have a flattened diastolic peak. In *E* is shown a lateral kymogram in which pulsation of the calcified plaques is seen. *F*, a postoperative kymogram, reveals good pulsations over the right border and the aorta with a marked increase in pulsations over the left border. The diastolic peaks have a more normal contour.

Representative preoperative and in some instances postoperative changes are illustrated in Figures 1 to 8.

In most cases roentgenoscopy proved to be of considerable diagnostic importance. In 6 the lateral shift of the heart with change in position and the downward descent with inspiration was markedly limited and in 5 of these the limitation was observed in the presence of normal movements of the diaphragm. In 2 other cases, however, these findings were not present, and in the other 8 in which they were sought, limitation of the motion of the diaphragms made their presence of less significance.[21] Pulsations were decreased over a large area of the cardiac silhouette in all cases, but in 4 the apex, and in 2 the pulmonary conus exhibited pulsations of normal or greater than normal amplitude.

FIG. 5. Case III. *A*, taken on June 1, 1935, and *C*, taken on March 28, 1939, show the appearance of the heart over a four year period prior to operation. *B* illustrates the extensive calcification visible in the lateral view. *D*, taken on February 12, 1940, nine months after operation, shows that the cardiac silhouette has increased in size and changed in configuration. *E* is a preoperative kymogram showing diminished pulsations with flattened diastolic peaks over the left border, absent pulsation over the aorta, and normal pulsations over the left border. *F* is a postoperative kymogram, illustrating the increase in amplitude of pulsations over the right border and aorta with more normal diastolic peaks.

Routine 2 meter roentgenograms of the heart in the posteroanterior and lateral positions also proved to be of great value in the study of these cases. Attention should be called to the chest cage itself as in most cases it has a distinct square shape with widening of the lower diameters presumably due to the long standing ascites with outward pressure on the costal margin and elevation of the diaphragms (Fig. 1). The cardiac silhouette itself was slightly smaller than normal in 3 cases, and in only 4 cases slightly enlarged. In 7 it was described as moderately enlarged (Fig. 2) and in 2 as markedly enlarged (Fig. 3 and 4). In 1 of the 2 cases in which marked enlargement was present there was persistent hypertension and in the second, although the heart was encased in an adherent pericardium 2 to 4 mm. thick and the capacity of the right ventricle reduced, the left auricle and ventricle were found to be dilated and the heart weight was estimated to be above the normal limits at autopsy. It was not possible to establish any direct relationship between the size of the cardiac silhouette and the thickness of the pericardium at operation or autopsy, the pericardial thickness varying from 2 mm. in a patient in whom the silhouette had appeared markedly enlarged to 8 mm. in one in which it had appeared slightly smaller than normal. After operation there was no constant alteration in the size of the cardiac silhouette; it appears, therefore, that factors other than the thickness of the pericardium are responsible for an apparent increase in the size of the heart. These may be dilatation of portions of the heart with constriction in others and disturbances in the relationship of various chambers of the heart to the chest wall. In 6 the shape of the heart was triangular (Fig. 4), in 9 distinctly globular (Fig. 2) and in 1 "boot shaped" (Fig. 3). In none was the silhouette normal since the usual subdivisions of the right and left borders were obscured. Definite extrapericardial adhesions were seen in only 4 patients. Calcification of the pericardium was demonstrated in 7 patients and established the diagnosis in the patient in which there was coexistent hypertensive heart disease. This was not always demonstrable in the posteroanterior view in cases in which lateral views showed extensive deposition of calcium (Fig. 1, 5 and 6). At operation an additional patient had sufficient calcification to suggest that a more careful search would have demonstrated its presence, in 4 others calcification found on microscopic examination of the pericardium removed at operation was probably undetectable. The superior mediastinum was normal in 7, in 5 was slightly wider, and in only 2 was it considerably wider than normal. The appearance of the aortic knob was a helpful sign in almost all cases. In 5 the aortic knob was not visualized, in 9 others it was small and flattened; and lateral views, moreover, showed the arch in these cases to be of small diameter (Fig. 1, 2 and 7). In only 2 cases was the aorta normal or larger in size and 1 of these was in the presence of hypertension in a man, aged fifty-eight, with evidence of arteriosclerosis elsewhere (Fig. 3). That the narrowing of the aorta cannot be attributed entirely to adhesions is indicated in those cases in which there is a postoperative increase in size despite the fact that the operative procedure does not extend to this region (Fig. 7), and it may be that the small size of the aorta is due, at least in part, to the reduced cardiac output which has been demonstrated.[29,30] After release of the obstruction with return of the output to normal the extent of increase in the size of the aorta is probably determined by adhesions.

The lung fields in all cases showed increase in the vascular markings and the hilar shadows were particularly heavy in most instances (Fig. 6). That there was little relationship between the prominence of these markings and the complaint of dyspnea was shown by those cases in which there was marked increase and in whom dyspnea was a minor symptom. The presence of calcium deposits at the hilum was the only evidence for preceding tuberculous

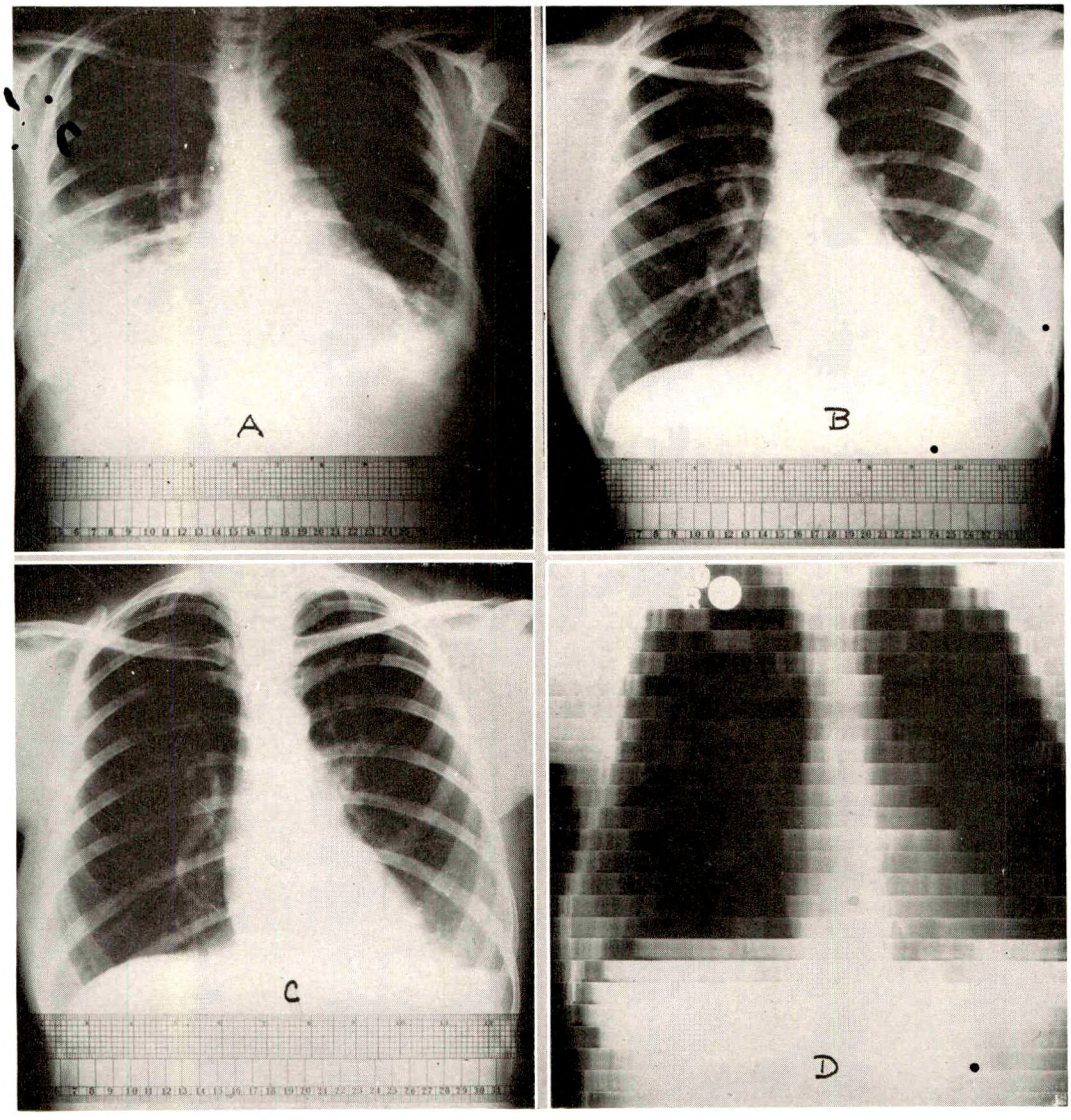


Fig. 7. Case 1. *A*, taken on January 27, 1936, shows a moderately enlarged triangular heart with loss of the normal subdivisions of the borders and absence of the aortic knob. *B* and *C*, taken on December 16, 1937, and November 22, 1940, one and four years after operation respectively, illustrate decrease in size of the silhouette, return to a more normal configuration, and the appearance of a normal aortic knob. *D* is a post-operative kymogram, taken on November 22, 1940, showing the normal amplitude of pulsation over the entire silhouette. Active tuberculous pericarditis was found at operation. The patient is apparently "cured."

infection in 5 cases. One patient had heavy bronchial shadows and pulmonary fibrosis suggestive of chronic pulmonary infection, but on the whole inflammatory changes were conspicuously absent. Eleven of the group had pleural effusion at one time or another prior to operation. Thoracenteses in these gave no evidence of a causative agent and the fluid had the characters of a transudate. Several had evidence of pleural thickening, however, and this may have been related to the original inflammatory process. The posterior mediastinum in all but one case was within normal limits of density. A finding of incidental interest, however, was a kyphotic tendency of the

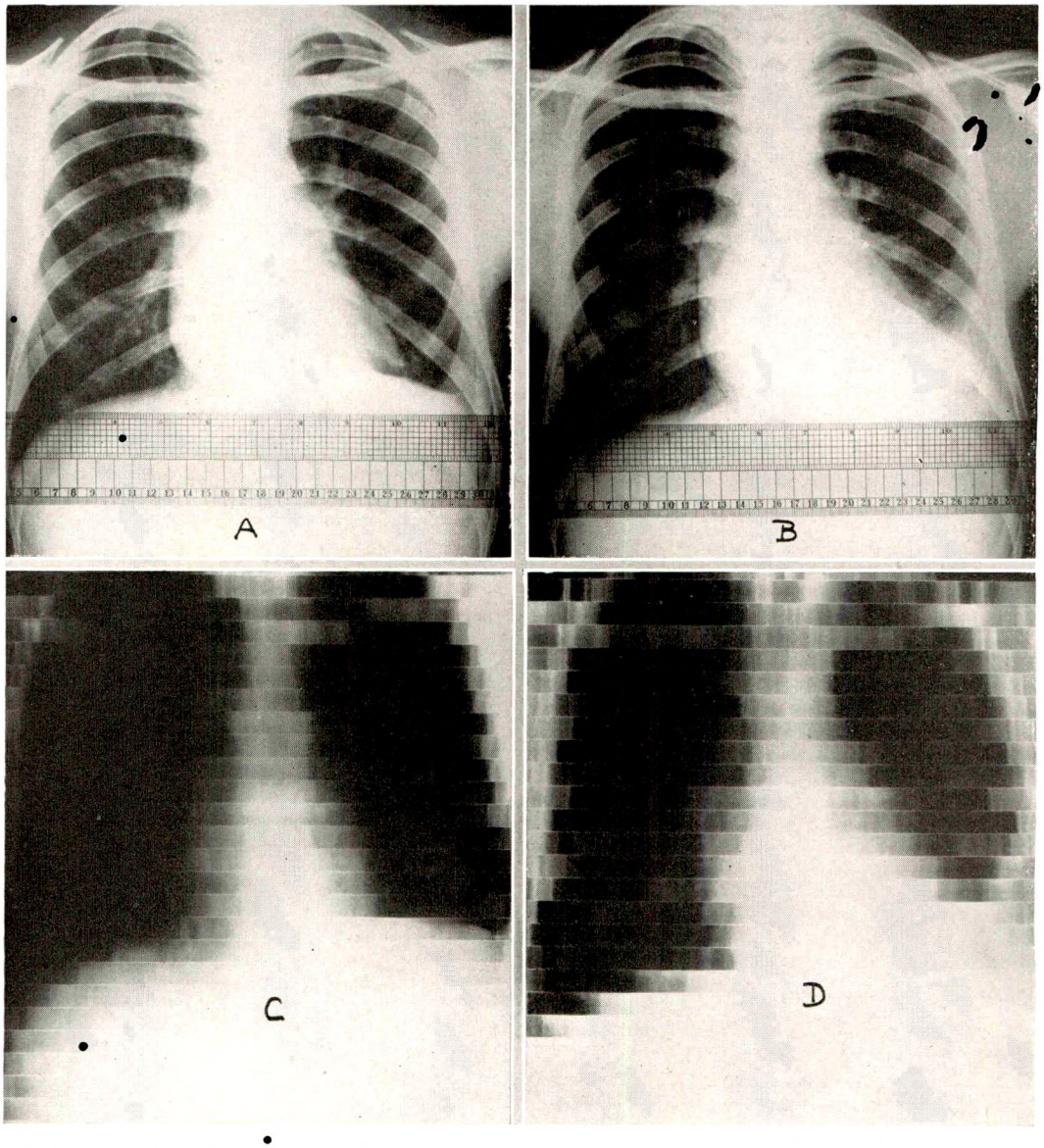


FIG. 8. Case XI. *A* and *C* are preoperative roentgenogram and kymogram respectively, taken on October 11, 1939. *B* and *D*, taken on February 21, 1940, three months after operation, illustrate the slight amount of roentgenologic improvement compatible with marked improvement in the clinical picture following pericardiectomy.

dorsal vertebra in 5 and of more than average amount of hypertrophic arthritic change of the dorsal spine in 3 cases.

The kymogram, contrary to the experience of others,[10,11] has been of considerable aid in the diagnosis chiefly because it offers a more accurate estimation of the degree of pulsation over the right border of the heart and over the aorta, areas in which the roentgenoscopic estimation is often difficult, and in which in all 10 of our cases where preoperative kymographic studies were done there was a significant reduction in amplitude. Five of these patients had chronic auricular fibrillation which made the limitation of pulsation along the right border (which is made up mainly of the right auricle) difficult to evaluate. At times

the flattening of the diastolic peak of the wave suggested abnormality when pulsations of fairly good amplitude were present (Fig. 6), but in most instances the amplitude of pulsation proved the most reliable sign. In some cases there were pulsations of normal or greater than normal amplitude over the upper left border in the region of the pulmonary conus, in others the pulsations at the apex were increased in amplitude. Postoperative kymograms uniformly showed increase in amplitude of the pulsations, particularly over the left border but that this increase in pulsation was not always related to the degree of clinical improvement as illustrated by a case in which only a slight general increase in the amplitude of pulsation is seen in a patient who is markedly improved (Fig. 8). In others a fairly marked increase in pulsation has been associated with only moderate improvement in the clinical condition. Pulsations of increased amplitude over the aorta may be of value in estimating the increase in cardiac output but are difficult to visualize, may be obscured by adhesions and are probably not reliable in many cases.

COMMENT

The roentgenologist's principal rôle in the diagnosis of chronic constrictive pericarditis lies in demonstrating the existence of scarring and adherence of the pericardium. Clinical and laboratory findings of obstruction to the venous inflow and diminution of the systolic output of the heart supply the evidence that these pericardial changes interfere with cardiac function. That thickening and adherence of the pericardium may exist without such disturbance is known,[17,27,28] and that adhesions between the heart, pericardium, and adjacent structures probably do not affect the heart or circulation in any way except by constriction and interference with the diastolic filling and systolic emptying of the heart has also been pointed out.[4,30] The most reliable signs of the presence of such an adhesive process in the pericardium appear to be the following: limitation of the lateral shift on change in position and of elongation of the heart on descent of the diaphragm, calcification in the pericardium, absence of or a small and flattened aortic knob, loss of anatomical configuration of the cardiac silhouette, pulmonary congestion, and the roentgenoscopic or roentgen kymographic demonstration of diminution of pulsation over all or part of the cardiac silhouette. None of these signs are pathognomonic in themselves and it is only by the composite picture of those that are present that the roentgenologist can suspect the presence of Pick's disease. When pericardial calcification is present in a patient exhibiting a compatible clinical picture it is the most reliable sign of all, particularly in those cases in which the size of the cardiac silhouette is increased. In the absence of calcification a sufficient number of other signs can usually be elicited to make the diagnosis possible. That lateral views are the most reliable in the demonstration of calcium and that heavy exposures are necessary at times should be kept in mind. Demonstration of extrapericardial adhesions, paradoxical motion of the diaphragm, and the width of the superior mediastinum have been of minor diagnostic value in this series.

The emphasis that has been placed on the small quiet heart in the diagnosis of chronic constrictive pericarditis may be justified in most cases on clinical grounds but too strict adherence to this principle may cause one to overlook the group in which there is roentgenologic evidence of considerable enlargement of the cardiac silhouette. In addition, failure to search for the signs which have been enumerated may forfeit the chance for possible successful surgery in the occasional case in which chronic constrictive pericarditis coexists with other types of cardiovascular disease. Illustrative of this point is Case IX in which hypertension and a large boot-shaped heart are present and a case in which Oppenheimer, Hitzig and Neuhof[18] relate the coexistence of rheumatic heart

disease with mitral stenosis and of chronic constrictive pericarditis with a pericardium 1.5 cm. in thickness. Unfortunately the roentgenologic observations in the latter case are not recorded.

CONCLUSIONS

1. Roentgenologic study is of considerable importance in the differential diagnosis of chronic constrictive pericarditis.

2. When venous engorgement, serous effusions, and hepatomegaly are present indicating obstruction to the flow of blood through the heart the composite roentgenologic picture pointing most conclusively to chronic constrictive pericarditis as a cause of this obstruction is as follows: a small or only slightly enlarged heart of abnormal configuration and often a rim of calcium at the periphery. The aortic knob is absent or flattened and deformed. Roentgenoscopic examination reveals the excursions of the margins to be diminished to the point that the heart seems almost to be standing still. When the patient is tilted from side to side the heart remains fixed in the midline and fails to elongate when the diaphragms move downward. Pulmonary congestion is usually evident, pleural thickening or effusion and extrapericardial adhesions deforming or imparting abnormal motion to the diaphragm may be found. The kymogram confirms the marked decrease in the amplitude of pulsation over the borders of the heart and of the aorta.

3. Roentgenoscopic signs in the order of their diagnostic importance are: (*a*) limitation of the lateral shift of the anatomical axis of the heart with changes in position; (*b*) limitation of the elongation of the heart with descent of the diaphragms when the heart is not greatly enlarged and there is no marked limitation of diaphragmatic motion; (*c*) decrease in the amplitude of cardiac pulsations over portions or all of the cardiac silhouette; and (*d*) paradoxic motion or deformity of the diaphragms due to the tugging of adhesions.

4. Calcification is the most reliable sign of chronic constrictive pericarditis especially when the cardiac silhouette is enlarged but is present in less than half of the cases and when present does not always indicate constriction of the heart. It is sometimes visible under the roentgenoscope but is best demonstrated in lateral roentgenograms and occasionally heavy exposures are necessary to demonstrate its presence.

5. In the absence of calcification the most common roentgenographic signs of chronic constrictive pericarditis are: (*a*) a small and flattened or absent aortic knob; (*b*) abnormal configuration of the cardiac silhouette, usually with a triangular or globular shape and loss of the normal subdivisions of the borders; and (*c*) evidence of pulmonary congestion.

6. The size of the cardiac silhouette, when small, is of considerable importance but a marked increase in size or evidence of cardiovascular disease of other etiology (hypertension and arteriosclerosis for example) does not necessarily rule out the diagnosis of chronic constrictive pericarditis. In these cases the diagnosis is more difficult but can usually be made from the composite roentgenologic and clinical pictures.

7. There was no constant relationship between the thickness of the pericardium removed at operation and the size of the cardiac silhouette in roentgenograms.

8. The roentgen kymogram is of considerable aid in the diagnosis especially in the study of the pulsations along the aorta and right border of the heart where the amplitude of pulsation was found to be most regularly reduced. In addition to the reduced amplitude of pulsation, flattening and irregularity of the diastolic peak of the wave is sometimes a helpful but less important finding. Pulsations of normal or greater than normal amplitude may be seen over portions or over all of the left border.

9. No constant changes in the size or appearance of the cardiac silhouette or of the aorta were observed following operation. Some hearts became larger, others small. Increase in the amplitude of pul-

sations in the kymogram were regularly seen over portions or over all the cardiac silhouette but could not be related to the degree of relief afforded by pericardiectomy.

REFERENCES

1. Beck, C. S., and Griswold, R. A. Pericardiectomy in treatment of Pick syndrome. *Arch. Surg.*, 1930, *21*, 1064–1113.
2. Beck, C. S., and Cox, W. V. Effect of pericardiostomy on mechanics of circulation. *Arch. Surg.*, 1930, *21*, 1023–1039.
3. Beck, C. S. Two cardiac compression triads. *J. Am. M. Ass.*, 1935, *104*, 714–716.
4. Beck, C. S. Acute and chronic compression of the heart. *Am. Heart J.*, 1937, *14*, 515–525.
5. Blalock, A., and Levy, S. E. Tuberculous pericarditis. *J. Thoracic Surg.*, 1937, *7*, 132–152.
6. Burwell, C. S., and Flickinger, D. Obstructing pericarditis. *Arch. Int. Med.*, 1935, *56*, 250–257.
7. Burwell, C. S., and Blalock, A. Chronic constrictive pericarditis. *J. Am. M. Ass.*, 1938, *110*, 265–271.
8. Churchill, E. D. Decortication of the heart (Delorme) for adhesive pericarditis. *Arch. Surg.*, 1929, *19*, 1457–1469.
9. Delorme. Sur un traitement chirurgical de la symphyse cardo-pericardique. *Bull. et mém. Soc. de chir.*, 1898, *24*, 918.
10. Freedman, E. Roentgenological diagnosis of cardiac compression due to pericardial scar; adhesive pericarditis. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 739–755.
11. Freedman, E. Inflammatory diseases of the pericardium. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 38–46.
12. Griswold, R. A. Chronic cardiac compression due to constricting pericarditis. *J. Am. M. Ass.*, 1936, *106*, 1054–1057.
13. Harrington, S. W., and Barnes, A. R. Diagnosis and surgical treatment of chronic constrictive pericarditis. *South. Surgeon*, 1940, *9*, 459–484.
14. Heuer, G. J., and Stewart, H. J. Surgical treatment of chronic constrictive pericarditis. *Surg., Gynec. & Obst.*, 1939, *68*, 979–1001.
15. Johnson, S. E. Roentgenkymograph as a new aid in diagnosis of adhesive pericarditis. *Surg., Gynec. & Obst.*, 1935, *61*, 169–174.
16. Keefer, C. S. Tuberculosis of pericardium. *Ann. Int. Med.*, 1937, *10*, 1085–1104.
17. Leaman, W. G., and Vastine, J. H. Calcification of the pericardium. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 35–41.
18. Oppenheimer, B. S., Hitzig, W. M., and Neuhof, H. Chronic constrictive pericarditis; medical and surgical aspects. *J. Mt. Sinai Hosp.*, 1941, *7*, 270–289.
19. Pick, F. Ueber chronische unter dem Bilde der Lebercirrhose verlaufende Perikarditis (pericarditische Pseudolebercirrhose). *Ztschr. f. klin. Med.*, 1896, *29*, 384.
20. Rehn, L. Ueber pericardiale Verwachsungen. *Med. Klin.*, 1920, *16*, 999–1003.
21. Roesler, H. Clinical Roentgenology of the Cardiovascular System. Charles C Thomas, Springfield, Ill., 1937.
22. Sauerbruch, F. Die delormesche Operation: Cardiolysis intrapericardica. Chirurgie der Brustorgane, 1918, *2*, 296.
23. Schmieden, V., and Volhard, F. Ueber die Erkennung und Behandlung der Umklammerung des Herzens durch schwielige Perikarditis. *Klin. Wchnschr.*, 1923, *2*, 5.
24. Schmieden, V., and Fischer, H. Zur Frage der schwieligen Perikarditis. *Schweiz. med. Wchnschr.*, 1926, *56*, 489.
25. Schmieden, V., and Westermann, H. H. Operative management of fibrous constricting pericarditis. *Surgery*, 1937, *2*, 350–358.
26. Scott, W. G., and Moore, S. Roentgenkymography; its clinical and physiological value in study of heart disease. *Ann. Int. Med.*, 1936, *10*, 306–329.
27. Smith, H. L., and Willius, F. A. Pericarditis. I. Chronic adherent pericarditis. *Arch. Int. Med.*, 1932, *50*, 171–183. Pericarditis. II. Calcification of the pericardium. *Arch. Int. Med.*, 1932, *50*, 184–191.
28. Sprague, H. B. Differential diagnosis of congestive heart failure and constrictive pericarditis (Pick's disease). *Am. Heart J.*, 1936, *12*, 443–447.
29. Stewart, H. J., and Heuer, G. J. Measurement of circulation in constrictive pericarditis before and after resection of pericardium. *Tr. Ass. Am. Physicians*, 1937, *52*, 342–343. Also, *New York State J. Med.*, 1939, *39*, 2183–2187.
30. Stewart, H. J., and Heuer, G. J. Chronic constrictive pericarditis; dynamics of circulation and results of surgical treatment. *Arch. Int. Med.*, 1939, *63*, 504–530.
31. White, P. D., and Churchill, E. D. Relief of obstruction of circulation in a case of chronic constrictive pericarditis (concretio cordis). *New England J. Med.*, 1930, *202*, 165–168.
32. White, P. D. Chronic constrictive pericarditis (Pick's disease) treated by pericardial resection. *Lancet*, 1935, *2*, 539; 597.

THE DIAGNOSIS OF CONGENITAL HEART LESIONS IN CHILDREN*

By G. W. GRIER, M.D.
Professor of Radiology, University of Pittsburgh
PITTSBURGH, PENNSYLVANIA

THE diagnosis of congenital anomalies of the heart and great vessels and particularly the identification of the lesion, or lesions, present is always difficult. Often no effort at identification is made beyond classifying the lesion as "with" or "without" cyanosis.

There is a general opinion that the roentgenogram is not of a great deal of value in the specific identification of these lesions. Being a radiologist and much interested in the subject, I have attempted to analyze the material which has passed through my hands in the last ten years in an effort to determine just what may or may not be expected of the roentgen ray in these cases. To this end the case records and roentgenograms of 254 cases diagnosed and indexed in the hospital records as congenital heart disease have been studied.

I wish to acknowledge here the valued assistance of Dr. Eva Carey and Dr. John M. Hill in the somewhat onerous task of studying in some detail this rather voluminous mass of records.

All but 13 of these cases have been seen at the Children's Hospital and since my experience has been almost exclusively limited to children, the remarks embodied in this article may be accepted as applying to infants or children.

Twenty-three of the 254 cases were discarded after an initial survey because it was felt that there was a reasonable doubt that they were congenital anomalies. Three were disproved by autopsy, 4 had positive autopsy but no roentgenogram, 7 had a history of rheumatism and the remaining 9 seemed to lack definite proof that the lesion was congenital. The remaining 231 cases are analyzed in Table 1.

One of the surprising facts brought out in this table is the relatively small number (about 10 per cent) of cases in which a specific diagnosis was not attempted beyond the generalization of congenital heart disease. Most of these undiagnosed cases occurred during the early part of the ten

TABLE I

	Cases
Ventricular defect	43
Ventricular defect plus dextroposed aorta	2
Ventricular defect plus patent ductus arteriosus	1
Interauricular defect including foramen ovale	28
Interauricular defect plus patent ductus arteriosus	13
Defect in both septa	11
Defect in both septa plus patent ductus arteriosus	3
Defect in both septa plus atresia of the aorta	1
Patent ductus arteriosus alone	21
Tetralogy of Fallot	9
Lutembacher's disease	3
Pulmonary stenosis	29
Pulmonary stenosis plus ventricular defect	7
Pulmonary stenosis plus interauricular defect	1
Aortic stenosis	5
Coarctation of the aorta	4
Coarctation of the aorta plus ventricular defect	1
Persistent right arch of the aorta	2
Transposition of great trunks	1
Malrotation of the heart	1
Tricuspid stenosis	2
Mitral stenosis	3
Dextrocardia alone	1
Dextrocardia with other cardiac anomalies	4
Dextrocardia with situs inversus	3
Cor biventriculare triloculare	3
Cor biatriatum triloculare	4
Cor biloculare	1
No differential diagnosis made (roentgen findings positive 9; negative 15; clinically positive 24)	24
	231

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

year period when our experience with roentgen diagnosis was slight. Unfortunately, most of the films of that period have been discarded and we are not able to review them now in the light of an increased experience. The fact that a specific diagnosis was made cannot, of course, be accepted as proof of the correctness of that diagnosis.

Forty-four cases came to autopsy, so we have at least that number in which we know the exact diagnosis. The roentgen appearance of these known cases is used as a basis for diagnosis, and although there are numerous individual variations and although the appearance may vary at different stages of the same case, there are certain general characteristics in several anomalies which make their recognition reasonably accurate. These will be described in detail later.

In addition to the 44 cases which came to autopsy, death occurred in 29 others in which autopsy was not granted, a total of 73 deaths in 231 cases while under observation.

While a strictly scientific approach to the subject might require exclusion of all cases that did not come to autopsy, such a course would not help much in furthering the object of this study; namely, increased accuracy in diagnosis. Many cases of congenital heart disease live beyond childhood and consequently would not come to autopsy during the age period covered by our observations.

For purposes of study, congenital heart lesions may be classified as follows:

1. Septal defects.
2. Anomalous chambers.
3. Anomalous great vessels.
4. Valvular lesions.

A subdivision of the four primary classifications follows:

Defects of the interauricular septum:

a. Patent foramen ovale.
b. Patent ostium primum.
c. Patent ostium secundum.
d. Absent septum.

Defect of the interventricular septum.

Ostium atrioventriculare commune.

Anomalous chambers:

a. Cor biventriculare triloculare—one auricle and two ventricles.
b. Cor biatriatum triloculare—two auricles and one ventricle.
c. Cor biloculare—one auricle and one ventricle.

Anomalous great vessels:

a. Patent ductus arteriosus.
b. Persistent truncus arteriosus.
c. Defect in aortic septum.
d. Aortic stenosis or atresia.
e. Pulmonary stenosis or atresia.
f. Transposition of great trunks.
g. Persistent right arch of aorta.
h. Coarctation of aorta.

Congenital valvular lesions:

a. Tricuspid.
b. Pulmonic.
c. Mitral.
d. Aortic.

Any of these valves may be the seat of developmental anomalies such as absence of one or more cusps, supernumerary cusps, or thickened and fibrotic cusps. The number of cusps may have no pathological significance, but the presence of any of the other defects usually results in stenosis at the valve. Congenital insufficiency is apparently very rare. In one of our cases, tricuspid insufficiency was found at autopsy. Valvular endocarditis is thought by some authors to occur in fetal life, but this is disputed by others. There were no such cases recognized in our series.

DEFECT OF INTERVENTRICULAR SEPTUM: ROGER'S DISEASE

This lesion is a common anomaly, thought by some to occur even more frequently than defects of the interauricular septum.

The defect is usually a small circular opening occurring high up on the septum and behind the septal segment of the tricuspid valve. Occasionally the opening is large and very rarely it occurs in the lower part of the septum. Usually the fibers of

the bundle of His extend around the opening, but if the defect is very large it may separate the bundle from the auriculoventricular node and thus produce heart block.

The blood flows from left to right through this opening except as a terminal event. The opening is surrounded by fibrous tissue which may have a tendency to contract and make the opening smaller. An area of fibrosis also develops at the spot on the wall of the right ventricle where the column of blood impinges with considerable force. These areas of fibrosis are significant because it is there that vegetations develop from the bacterial endocarditis which eventually supervenes in many cases.

Rarely the opening may merge with a patent ostium primum in the interatrial septum, thus producing a defect which opens into all the chambers of the heart. The cusps of both the tricuspid and mitral valves are almost certain to be involved if the opening is at all large. Cyanosis is usually not very great. Mongolism is said to occur very frequently in this particular defect.

Complete absence of the ventricular septum (cor biatriatum triloculare) allows free mixture of arterial and venous blood and is naturally accompanied by some cyanosis, but cases of this sort have been known to reach the age of thirty-five years.

Small defects in the ventricular septum have no clinical significance and are accompanied by no symptoms in the absence of endocarditis. A loud prolonged systolic murmur is present, heard most distinctly in the third and fourth interspaces close to the sternum. A thrill accompanies the murmur in about one-third of the cases. Cyanosis is usually absent. In small infants it may develop on exertion. Clubbing of the fingers occurs only in the terminal stages. There is no dyspnea. The lesion is compatible with normal adult life if it occurs alone. However, it often occurs in combination with other anomalies. Occurring as a solitary lesion the chief danger is endocarditis.

The extra flow of blood into the right ventricle causes enlargement of that chamber and also of the pulmonary artery. The left ventricle is somewhat less prominent than normal. The enlargement of the right ventricle pushes the heart up off the diaphragm and on the roentgenogram the apex is quite a distance above the diaphragm instead of resting on it in the usual manner. The left ventricle is not nearly as full as normal, but the bulge of the pulmonary conus is exaggerated.

The entire heart silhouette bears a striking resemblance to a wooden shoe, the classical "coeur en sabot" so frequently described in the literature. At this stage the roentgen appearance is diagnostic. Sometimes in terminal stages the marked enlargement of the heart gives it a more or less globular appearance which is no longer characteristic.

In this series, 43 cases were diagnosed interventricular defect alone; 2 in combination with a dextraposed aorta; 1 with a patent ductus arteriosus; 9 as a part of the tetralogy of Fallot; and 15 in combination with atrial defects—a total of 70 cases out of 231.

The roentgen appearance is possibly the most characteristic of all congenital heart anomalies. The wooden shoe-shaped heart with the apex pushed up off the diaphragm by the enlarged right ventricle is easily recognized and quite characteristic. The case presented here is perhaps more globular in shape than is usually seen, but I think the general effect is unmistakable.

Case 1 (Fig. 1). R. B., white male infant, aged five months. Admitted to the Hospital September 1, 1939, because of cyanotic attacks.

The child had the typical appearance of mongolian idiocy. He had a fine papular rash over the entire body. He had an acute tonsillitis and pharyngitis at time of admission. Roentgenogram of chest showed a consolidation of both upper lobes, diagnosed bronchopneumonia. The heart was somewhat enlarged and the shadow of the great vessels was smaller than normal. The roentgen appearance was thought to indicate a congenital heart lesion.

The cardiologist reported the heart enlarged to the right; pulsations forceful, rapid and regu-

lar. The heart sounds were rough. There was a harsh systolic murmur at the apex. The diagnosis was congenital heart lesion, probably ventricular septal defect.

The child died on September 15, 1939, from a pneumonia.

Autopsy of the heart showed a marked dilatation of the right auricle. The aortic and pulmonary arteries were normal in size and position and the ductus arteriosus was not patent. The bicuspid and tricuspid valves were not thickened and there were no vegetations. There was a defect in the interventricular septum measuring approximately 0.5 by 0.75 cm.

Diagnosis: Patent interventricular septum.

When defects occur in both the interatrial and interventricular septa, the shape of the heart includes the characteristics of both. The left side of the heart has the typical wooden shoe effect and on the right side the auricle is unusually prominent. Sometimes the shadow of the ascending aorta is absent, but in some cases a rather rectangular supracardiac shadow is noted. Other defects are not uncommon and in such cases loss of compensation occurs

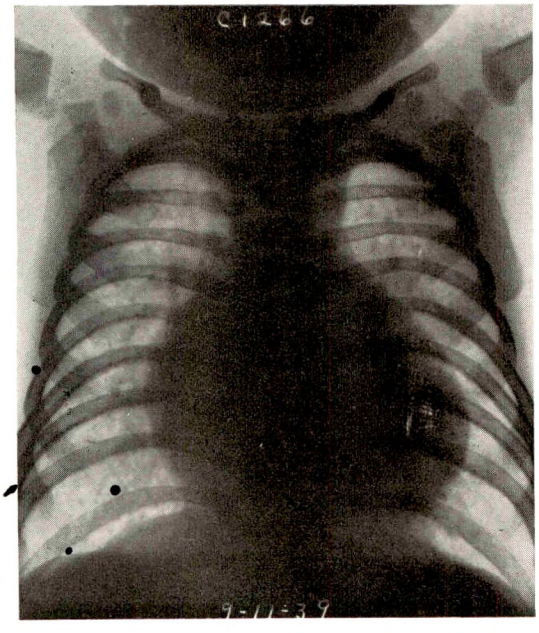


Fig. 1. Case I. Large interventricular septal defect. Note marked enlargement of the right heart and the upward displacement of the heart with the apex high up off the diaphragm.

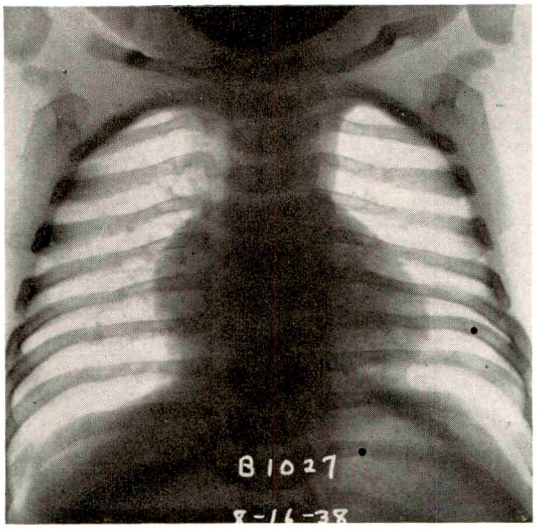


Fig. 2. Case II. Patent foramen ovale and patent interventricular septum. Characteristics of both defects are present; namely, dilated right auricle, absence of shadow of ascending aorta, and upward displacment of the heart with the apex off the diaphragm.

early and the heart becomes extremely enlarged. At that stage the characteristic shape no longer prevails and differential diagnosis is not possible.

Of the 15 cases we have seen, 11 presented a sufficiently characteristic silhouette to justify a positive diagnosis. The following case is a typical illustration:

Case II (Fig. 2). D. D., white male, aged six months. Admitted to the Hospital August 15, 1938. The baby had a fever and diarrhea. He was one month premature, but had no trouble until the present complaint.

The child was well developed, had a mongolian expression and marked tendency to cyanosis. Liver was quite enlarged. Nails were cyanotic, but there was no clubbing. The heart was enlarged on percussion, but no murmurs noted.

Roentgen examination showed a marked enlargement of the heart which involved all the chambers.

The child was readmitted on March 22, 1939, at which time examination of the heart revealed roughening of the first sound at the apex. There was a sinus arrhythmia. At the end of one week the child developed erysipelas from which he promptly died.

At autopsy, the heart was markedly enlarged,

occupying most of the thorax. There was a small patent foramen ovale. There was a moderate thickening of the right ventricular wall. There was a defect in the upper portion of the ventricular septum 1.5 cm. in diameter. A persistent truncus arteriosus straddled the defect in the septum. The three vessels in the arch of the aorta arose from their usual position. The pulmonary artery arose just distal to the left subclavian.

Diagnosis: Patent foramen ovale; patent interventricular septum; persistent truncus arteriosus.

DEFECT OF INTERAURICULAR SEPTUM

This lesion is usually considered to be the most common of all congenital heart anomalies. If those cases in which the foramen ovale presents a slit-like opening covered by a flap on the left side of the septum are included, this is undoubtedly true. Various observers have reported from 30 to 44 per cent of all autopsies as presenting a potential opening of this type, which in most cases does not allow leakage because the higher pressure on the left side keeps the flap closed.

An incompetent foramen ovale probably develops from a combination of two causes: (1) a reversal of the usual situation in which the pressure on the right side of the heart becomes greater than the left. This could be brought about by an obstruction of some sort, for instance other congenital anomalies at the tricuspid or pulmonary valve areas, or increased pressure in the pulmonary circulation from congestion, atelectasis, or any acute pathological condition in the newborn; (2) the dilatation of the right heart, particularly the auricle, which results from this obstruction, stretches the opening of the foramen and makes it incompetent. When the foramen ovale is incompetent the opening is no longer slit-like, but presents a gap which the flap cannot cover.

The foramen ovale is in the upper part of the septum.

Defects in the lower part of the septum are due to a persistence of the ostium primum. The opening due to this cause may be of any size, even involving the entire septum and producing a three-chambered heart which has one auricle and two ventricles—"cor biventriculare triloculare."

The ostium secundum is at the upper end and posterior portion of the septum and can also be patent. The result of an opening in the interatrial septum is a flow of blood from the left auricle back into the right. The blood continues to flow in this direction as long as the systemic pressure remains higher than the pulmonic pressure. This may go on indefinitely if there are no other heart lesions to interfere with a free flow in the right side of the heart, if the myocardium remains normal and nothing happens to raise the pressure in the pulmonary circulation.

Under these circumstances, the only symptoms are those of deficient circulation, with general under-development, pallor, weak pulse and low blood pressure. In our experience a number of cases of mongolism have been noted. Cyanosis is not present unless a reversal of flow develops with venous blood mixing with arterial. This naturally occurs in the terminal stages of the disease, but until then moderate sized defects are symptomless unless complicated by other anomalies. Abbott reports only 36 out of 112 cases of patent foramen ovale uncomplicated by other lesions.

As a result of the extra blood flowing back into the right auricle, this chamber becomes dilated, followed by an enlargement also of the right ventricle and pulmonary artery. For the same reason, that is, less blood in the left side of the heart, these chambers are smaller than normal and the shadow of the ascending aorta and arch are very small and often not seen to the side of the spine in the roentgenogram.

This produces a very characteristic silhouette on the roentgenogram. The heart is quite enlarged, there is a decided accentuation of the pulmonary arc on the left border, the shadow of the ascending aorta is absent and the aortic knob very small, or absent. The heart has a rather globular shape. In extreme enlargement the right

ventricle may push the heart up off the diaphragm, producing the wooden shoe silhouette seen in defects of the interventricular septum. In general, the roentgen appearance is so characteristic as to be quite diagnostic.

There is no difference in the roentgen appearance between patent foramen ovale and patent ostium primum or secundum. However, there is one point which may have some value in differentiation. The opening in defects of the septum practically always allows more leakage than a patent foramen ovale because it is larger and there is no flap to interfere. If a series of roentgenograms shows a rapid increase in the size of the heart, the lesion is more likely to be a defect of the ostium.

Interatrial defects, particularly patent foramen ovale, are not inconsistent with normal living and many cases reach early or middle adult life.

One complication which may prove fatal is an aneurysmal dilatation of the pulmonary artery. When this occurs, cyanosis and dyspnea become marked, there is clubbing of the digits, the heart is very large, the precordium may bulge, the systolic murmur becomes louder and blowing in character. On the roentgenogram the shadow of the pulmonary conus is much exaggerated, the lungs show evidence of congestion, the hilar shadows are enlarged and the heart much larger than before.

A certain percentage of cases of interatrial defect develop mitral insufficiency, or mitral stenosis, particularly the latter, which is called Lutembacher's disease. There has been some dispute as to whether the mitral lesion is also congenital. Lutembacher thought the stenosis at the mitral valve was congenital and primary, and that the obstruction to the free flow of blood which resulted from it prevented the normal closure of the foramen ovale.

Other observers think that mitral disease is acquired. When this combination exists, a dilated left auricle is added to the changes already described. This causes the heart to be larger and even more globular in appearance. At roentgen examination the enlarged left auricle may be detected on an oblique view. Patients with this combination have also been known to reach adult life and lead an essentially normal existence.

In this series, 28 cases were diagnosed interatrial defect or patent foramen ovale, 13 atrial defect plus patent ductus arteriosus, and 3 atrial defect plus mitral stenosis, a total of 44 cases.

This compares with a total of 46 cases of interventricular defect, a slight preponderance of the latter, but essentially the two are about equally common and definitely more numerous than any other anomaly.

Our cases emphasize what has already been pointed out. The roentgen appearance is quite definite and characteristic and I believe can be relied upon for diagnosis. The marked dilatation of the right auricle, the fullness in the region of the pulmonary conus and the hypoplasia of the aorta are all easily recognized and have diagnostic value. They are illustrated in the following typical case:

Case III (Fig. 3). R. A. H., white male, aged three months. Admitted to the Hospital on October 17, 1940.

This child has always had a noisy respiration, particularly when taking a bottle. He had fever for the previous twenty-four hours.

Examination of the chest revealed scattered râles over both lungs, dullness in the right upper lobe.

A roentgenogram of the chest revealed bronchopneumonia in both upper lobes. The general appearance of the child suggested mongolism. He was discharged October 24, 1940.

He was readmitted on November 5, 1940, because of vomiting and diarrhea. His condition became steadily worse and he died on November 23, 1940. The immediate cause of death was acute pancreatitis.

Autopsy revealed patent foramen ovale, but the heart was otherwise normal.

Interatrial defect complicated by a patent ductus arteriosus throws an additional amount of blood into the pulmonary artery

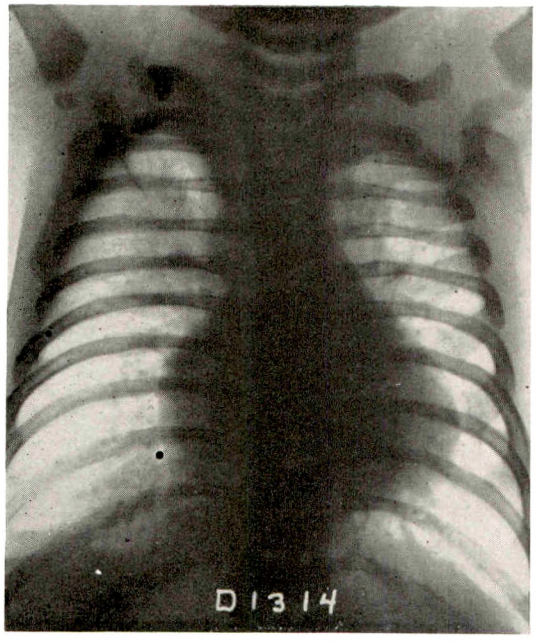


FIG. 3. Case III. Patent foramen ovale. Note marked enlargement of the right auricle and absence of the normal shadow of the ascending aorta.

from the aorta and increases the enlargement in the region of the pulmonary conus. In the presence of the other signs of atrial defect, if the pulmonary conus is extraordinarily large, a complicating patent ductus arteriosus may be inferred. The following case, while it has not come to autopsy, is presented as a probable example of this combination.

CASE IV (Fig. 4). J. A., colored female, aged four months. Admitted to the Hospital April 20, 1941, with history of cough and fever for the past five days.

Physical examination showed the child to be acutely ill. She had a mucopurulent discharge from the nostrils, and an area of dullness on percussion over the left lung. A diagnosis of bronchopneumonia was made. The child was placed on sulfathiazole and recovered promptly from the pneumonia.

Roentgen examination showed a marked enlargement of the right heart and dilatation in the region of the pulmonary artery. The shadow of the ascending aorta was much smaller than normal. The appearance was thought to be due to patent foramen ovale accompanied by patent ductus arteriosus, because of the marked enlargement in such a small infant.

The child was discharged on April 28, 1941, with a diagnosis of bronchopneumonia, secondary anemia and congenital heart disease.

Diagnosis: Patent foramen ovale; patent ductus arteriosus.

The combination of an atrial defect and mitral stenosis is recognized by a dilated right auricle, an absence of the normal shadow of the ascending aorta and a marked enlargement of the left auricle. This has been called Lutembacher's disease and is illustrated in the following case which did not come to autopsy, but is submitted as a probable example.

CASE V (Fig. 5). R. M. H., white female, aged two and one-half. Admitted to the Hospital on December 4, 1939, for observation.

The child became blue around the nose and mouth when playing and at times she would be so weak and dizzy that she had to stop. She had a poor appetite and very little energy. She exerted herself only on much urging.

Urinalysis and blood count were normal. Tuberculin test was negative. Pyelogram of the kidneys was normal. The heart sounds were normal; no murmurs heard.

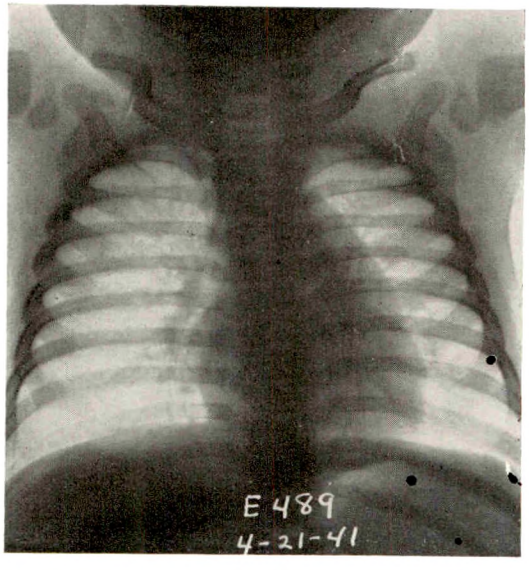


FIG. 4. Case IV. Patent foramen ovale and patent ductus arteriosus. In addition to the characteristics of patent foramen ovale, there is a marked bulging in the region of the pulmonary conus which is unusually large because both defects tend to dilate the pulmonary artery.

Roentgenogram of the chest showed an enlargement of the left ventricle, also enlargement of the right auricle and marked prominence of the left auricle. The shape of the heart suggested mitral stenosis plus patent interauricular septum.

The child was discharged with a clinical diagnosis of congenital heart disease, probably patent interauricular septum.

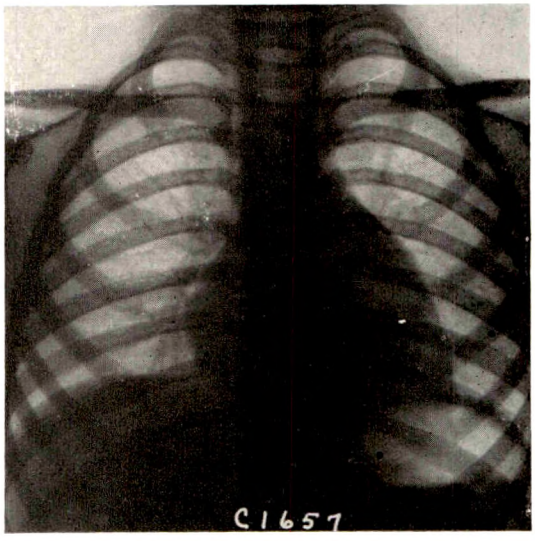


Fig. 5. Case v. Interatrial defect plus mitral stenosis. In addition to the characteristic enlargement of the right auricle and absence of the ascending aorta, there is also a marked enlargement of the left auricle.

PATENT DUCTUS ARTERIOSUS

The ductus arteriosus is a small vessel normally about 1 cm. long and 5 mm. in diameter, which connects the aorta in the region of the arch with the pulmonary artery. It has no function in post-natal life and closes within three weeks of birth. As a matter of fact, the work done recently by Barclay and others would seem to indicate that it closes within a few minutes of birth.

Its closure is brought about by the elevation of the systemic blood pressure after birth which makes pressure against and closes the aortic end.

Different conditions may prevent this normal sequence of events. Atelectasis of the lungs has been suggested as one cause. Other congenital anomalies which cause a back pressure in the right side of the heart may cause the blood to flow backward through the ductus and prevent its closure. This anomaly is often seen in combination with interventricular defects or pulmonary stenosis, occasionally with patent foramen ovale. About two-thirds of all cases have an associated anomaly. For some reason it is seen much more frequently in the female.

The flow of blood is from the aorta into the pulmonary artery and if the lesion is uncomplicated, there is no cyanosis or other symptoms except those which are brought about by poor systemic circulation such as pallor, anemia, under-development and general signs of arterial depletion. After some unusual exertion, crying, coughing, or anything to raise the pulmonary circulation, the blood flows temporarily from the pulmonary artery into the aorta and a transient cyanosis occurs. Where there are other anomalies which eventually bring about a reversal of flow the cyanosis is, of course, constant.

The result of the shunt into the pulmonary artery is a dilatation of that structure which may reach a great size, more or less aneurysmal in character and rupture of the ductus is one of the causes of death.

If the ductus is not very large, the only change in the heart may be a hypertrophy of the left ventricle in its effort to compensate for the lack of blood in the systemic circulation. If other anomalies are associated there is a general enlargement of the heart.

In late stages an insufficiency of the pulmonary valve may develop as a consequence of the greatly dilated pulmonary artery and this is followed by a dilatation of the right side of the heart. A characteristic murmur is present in about one-third of all cases which persists through both systole and diastole, and because of its to and fro quality has been called a "machinery murmur." If present it is diagnostic of the lesion.

The systolic portion of the murmur is supposed to be generated in the ductus, the

diastolic portion in an incompetent pulmonary valve. It is heard best in the second interspace on the left side and is accompanied by a thrill. Radial pulse may be unequal, the left larger than the right. The electrocardiogram is not characteristic. There is a marked tendency toward the development of infective endocarditis which is often fatal. Calcified areas often develop at either end of the ostia and these predispose to rupture.

Of 92 cases reported by Abbott, 28 died of endocarditis, 24 of decompensation, 16 of sudden heart failure and 2 of rupture of the ductus.

The roentgen appearance is quite characteristic in uncomplicated cases and before loss of compensation has taken place. Under these circumstances there is a marked enlargement of the pulmonary conus, often so great as to completely distort the normal shape of the pulmonary arc. The heart itself is of normal size and shape with the possible exception of an enlarged left ventricle. The ductus itself cannot be seen because of its location and its very short course. The dilated pulmonary artery when watched by roentgenoscope decreases in size with forced inspiration, and increases in size with forced expiration. Pulsation in both aorta and pulmonary artery is increased in vigor.

It is quite important to be able to recognize complicating anomalies, since uncomplicated cases may be operated upon and if this is done before endocarditis develops, cure is possible. Where the ductus is not very large, roentgen examination is extremely helpful as the marked dilatation of the pulmonary conus and the absence of other changes in the heart are quite typical.

The other common causes of a dilated pulmonary conus are pulmonary stenosis and interauricular defects. The latter produces other characteristic roentgen changes as already described, and the other two can usually be differentiated clinically, especially if the "machinery murmur" is present.

Cases which are complicated by other congenital defects present many difficulties in diagnosis, some of which are discussed elsewhere in this article. In the main, general enlargement of the heart or marked enlargement of specific chambers is suggestive of complicating anomalies.

In this series of cases, there were 21 which were diagnosed patent ductus arteriosus alone, and 18 which occurred in combination with some other lesion. As already stated, the characteristic roentgen changes are a dilatation of the pulmonary conus, usually accompanied by an enlargement of the left ventricle. If in addition the characteristic "machinery murmur" is heard, there can hardly be any doubt as to the diagnosis.

The other congenital anomaly which often presents a similar roentgen appearance, namely, pulmonary stenosis, has a different type of murmur and should be easily differentiated clinically.

The characteristic findings of an enlarged left ventricle and accentuated pulmonary conus are well illustrated in the following case:

CASE VI (Fig. 6). E. M., white female, aged two months. Admitted to the Hospital on May 30, 1941.

The child was well until it was about one month old, but at that time began to vomit and was losing weight; she was extremely emaciated. There was a loud blowing systolic murmur heard over the base of the heart.

The cardiologist examined the patient and thought she had a patent ductus arteriosus.

A roentgenogram was made which showed an enlargement in the region of the right auricle and also in the region of the pulmonary conus. There was an absence of the aortic knob. The appearance was thought to be suggestive of patent foramen ovale plus patent ductus arteriosus.

The child was discharged on June 15 and readmitted on June 23 with a bronchopneumonia from which she died on the following day. Autopsy was not performed.

Diagnosis: Patent ductus arteriosus.

Where a patent ductus arteriosus occurs in combination with a patent foramen ovale, the presence of both may be inferred

by the rapidity with which the pulmonary conus enlarges, due to the fact that additional blood reaches this region by way of both anomalies; that is, backward through the ductus and from the left auricle to the right auricle, into the right ventricle and to the pulmonary artery.

The combination of patent ductus arteriosus with ventricular septal defects, or with anomalous chambers, cannot be demonstrated by roentgen examination, to the best of my knowledge.

It apparently requires more than a few days after birth for the dilatation of the pulmonary artery to develop in an uncomplicated case of patent ductus. One case which died on the third day, and 2 cases which died on the fourth day, came to autopsy and although all of them presented a patent ductus and nothing more, the roentgenograms which had been made of all failed to show an enlarged pulmonary conus, or any other abnormality of the cardiac silhouette.

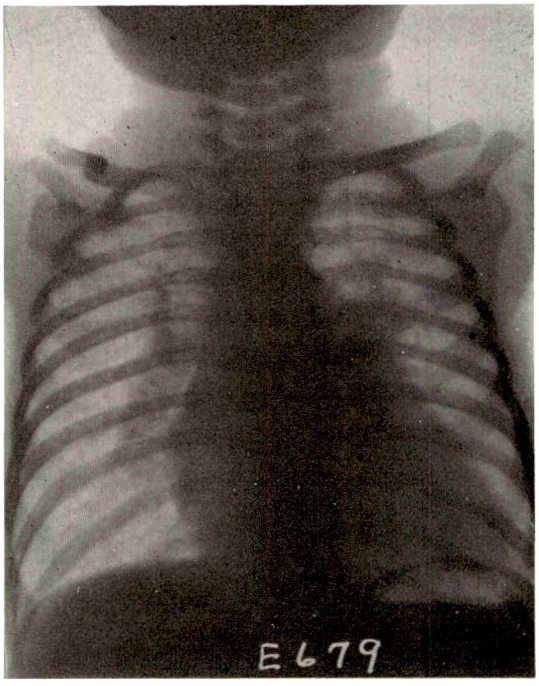


FIG. 6. Case VI. Patent ductus arteriosus. Note marked bulging in the region of the pulmonary conus.

TETRALOGY OF FALLOT

The four lesions which make up the tetralogy are:

1. Ventricular septal defect.
2. Pulmonary stenosis.
3. Dextroposition of aorta.
4. Hypertrophy of right ventricle.

The defect in the septum is high up under the cusps, is often round with smooth edges and may be large or small.

The pulmonary stenosis usually combines a stenotic valve, often bicuspid according to Abbott, with hypoplasia or atresia of the pulmonary artery. The pulmonary conus is narrow and deformed. Probably the narrowing of the artery is mainly due to a misplaced aortic septum encroaching upon the pulmonary side, as an enlarged widened aorta is also a part of this combination.

The aorta is unusually large and is displaced toward the right. It opens opposite the septal defect and receives blood from both ventricles.

The right ventricle is enlarged from hypertrophy in an effort to overcome the obstruction of the pulmonary stenosis, and also because of the back flow through the defect in the septum. Because of the disproportionate enlargement of the right ventricle, the heart is pushed up off the diaphragm and the apex displaced upward, producing the "coeur en sabot" appearance previously mentioned as being characteristic of defects of the interventricular septum.

However, the roentgen appearance in the tetralogy of Fallot differs from that of an uncomplicated ventricular septal defect because of the other anomalies present. The stenosis of the pulmonary artery and conus produces a concave effect instead of the normal pulmonary arc, and the widened and displaced aorta is easily recognized definitely to the right of its normal location. Taken together, these changes are specific and not difficult to recognize, so that the roentgen diagnosis is quite reliable.

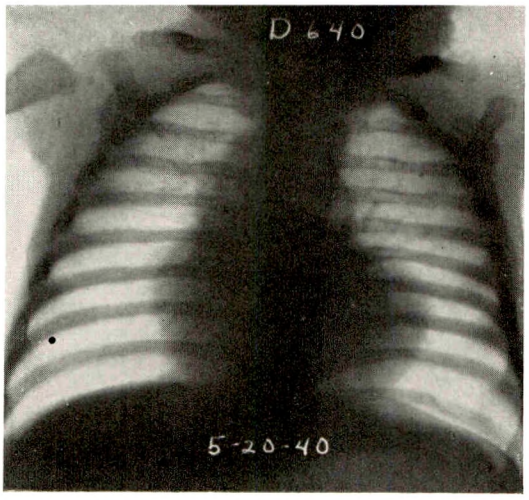


FIG. 7. Case VII. Tetralogy of Fallot. The interventricular defect produces the characteristic wooden shoe shape. There is a concavity in the region of the pulmonary conus produced by pulmonary stenosis, the right heart is quite enlarged and the ascending aorta is displaced to the right.

The cyanosis in these cases is rather marked and is accompanied by clubbing of the extremities and polycythemia which may reach 8 or 9 million. The increase in red cells in these cases is, of course, Nature's effort to compensate for the insufficient oxygenation of the blood.

There is a systolic murmur heard best in the right second interspace.

The electrocardiogram shows a marked right axis deviation.

In spite of the severity of this combination of lesions, patients may reach adult life. Constant engorgement of the pulmonary vessels, or gross enlargement of the right ventricle is the most common indication of early failure.

In this series, 9 cases have been diagnosed tetralogy of Fallot. As stated above, the roentgen appearance is quite characteristic. To the "coeur en sabot" already described is added a concave deformity in the region of the pulmonary conus brought about by the pulmonary stenosis. The right heart is quite enlarged, both auricle and ventricle participating, and the ascending aorta is dilated and bulges to the right as a result of the dextroposition which is a part of the complex. Taken together, the roentgen silhouette of the heart is diagnostic and can hardly be mistaken.

The following is a fairly typical example, although a patent ductus is added to the tetralogy of Fallot.

CASE VII (Fig. 7). J. B., colored male, aged two months. On May 18, 1940, admitted to the Hospital with a temperature of 103° F., lips and nail beds were cyanotic. The parents said the child had been cyanotic since birth.

Both ears were found to be infected and pus was draining. The baby was placed in an oxygen tent. Examination failed to reveal any pathologic lesion in the lungs or heart, although the heart sounds were not heard very well.

Roentgen examination of the chest showed an enlargement of the left ventricle, the heart having a typical wooden shoe appearance characteristic of patent interventricular septum. There was also an abnormal dilatation in the region of the ascending aorta.

The patient did badly and died four days later.

At autopsy, the heart showed a marked hypertrophy of the right ventricle. The pulmonary artery was atresic and consisted merely of a thin fibrous band to a point where it was joined by a patent ductus arteriosus which measured 5 mm. in diameter. Beyond this the pulmonary artery was normal. There was a defect in the ventricular septum. The aorta arose opposite the defect and astride the ventricular septum. It was dextroposed, but bore sharply to the left and across the left bronchus.

Diagnosis: Tetralogy of Fallot; patent ductus arteriosus.

EISENMENGER COMPLEX

This name has been suggested by Abbott to describe a combination of congenital anomalies identical with the tetralogy of Fallot except that the pulmonary stenosis or hypoplasia is absent. The lesions present are a defect of the interventricular septum, a dextroposed aorta and hypertrophy of the right ventricle.

The symptoms are not quite so severe in these cases, the cyanosis is moderate, and clubbing, etc., set in much later.

The lesion is distinguished by roentgen examination in that the pulmonary arc is

increased instead of being diminished as in the tetralogy of Fallot. Otherwise the heart is dilated and the apex displaced upward and the aorta dilated as in the tetralogy of Fallot.

We have 2 cases diagnosed as the Eisenmenger complex, but neither has come to autopsy and they are not included in this report.

PULMONARY STENOSIS OR ATRESIA

Under this heading may be considered stenotic lesions of the pulmonic valve, constriction in the region of the pulmonary conus, constriction of the pulmonary artery just beyond the conus and complete occlusion in the same location.

Stenosis of the valves may arise from developmental defects, or adhesions of the cusps, or from fetal endocarditis.

Fetal endocarditis is presumably rare. According to Brown, congenital syphilis may cause myocarditis, but not endocarditis. Myocarditis may result in fibrous tissue formation and thus be the cause of atresia in the great vessels.

In valvular stenosis the cusps are thickened or fused and form a funnel-shaped opening. If no other lesion is present the cyanosis is usually slight and may not appear until adult life, when there is dyspnea on exertion and epistaxis. If the obstruction is considerable the foramen ovale is almost certain to be patent.

The right ventricle is hypertrophied in valvular stenosis and the heart may present the typical wooden shoe enlargement. If the tricuspid valves also are involved, the right auricle will be dilated. Where valvular stenosis is due to endocarditis, the lesion is progressive as the vegetations tend to increase. In advanced cases there is marked cyanosis, clubbing of fingers, stunted growth and polycythemia. There is a harsh systolic murmur heard best in the second and third interspaces on the left, which is accompanied by a thrill. The pulmonic second sound is absent. Uncomplicated lesions of the pulmonary valve are rare.

Stenosis in the pulmonary conus is caused by an encircling muscular or fibrous band which tends to produce an extra chamber between the pulmonary artery and the pulmonic valve. Vegetations are apt to form at the orifice of this false chamber as well as at the valve.

Roentgen examination shows an accentuation of the pulmonary arc on the silhouette of the left heart and dilatation of the right auricle. If the obstruction is marked the right ventricle enlarges also, followed by dilatation of the left heart and aorta. In terminal stages the entire heart is greatly enlarged.

Constriction of the pulmonary artery beyond the conus presents the same picture clinically and by the roentgenogram as does conus stenosis. These lesions are seldom uncomplicated, being usually accompanied by patent foramen ovale, interventricular septal defects, or patent ductus arteriosus.

In pulmonary atresia, the artery is completely obstructed beyond the conus and for some distance is represented only by a fibrous cord. If there are no other congenital defects to allow the blood to be shunted to the lungs, life is very short. The right ventricle is extremely rudimentary, forming a cor biatriatum triloculare. There is extreme cyanosis from birth and death occurs in a few hours or days. Roentgen examination shows a dilated right auricle and aorta with hypertrophy of the left ventricle.

Complete atresia is usually accompanied by other defects. The most common combination is a patent foramen ovale and ductus arteriosus. The blood then flows backward from the right into the left auricle, left ventricle to the aorta and through the ductus arteriosus into the pulmonary artery beyond the obstruction and thus to the lungs.

Another combination of defects includes a patent ductus arteriosus plus a defect in the interventricular septum. Here the blood is shunted from the right ventricle into the left, to aorta, through the ductus to the pulmonary artery beyond the obstruction. This is essentially the tetralogy of Fallot,

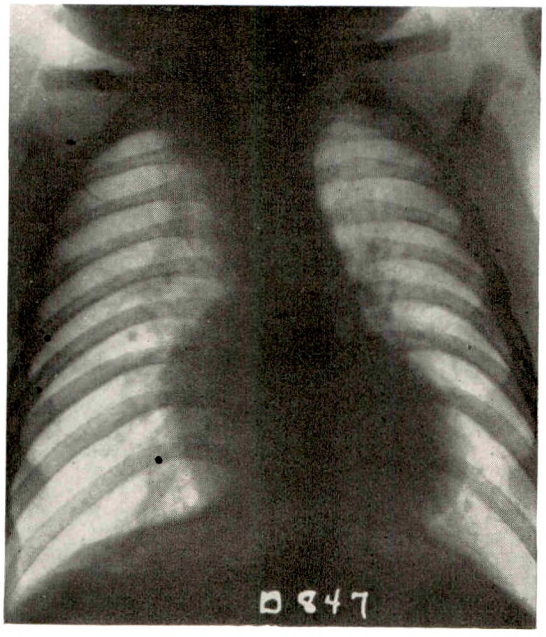


Fig. 8. Case VIII. Diagnosed pulmonary stenosis by the cardiologist. There is a concavity in the region of the pulmonary conus and marked dilatation of the right side of the heart.

the only addition being the dextroposed aorta. Sometimes there is a defect in both the auricular and ventricular septa, in addition to the pulmonary atresia.

Pulmonary atresia is one of the most serious of all congenital defects and even where other anomalies allow a venous-arterial shunt, the incapacity is great and complications and loss of compensation occur comparatively early. The typical roentgen appearance is that of a greatly enlarged heart, both right and left, and a dilated aorta.

In this series, pulmonary stenosis alone was diagnosed in 29 cases, in combination with a ventricular defect in 7, and with an interauricular defect in one.

In addition, it was present in 8 cases of the tetralogy of Fallot, 3 cases of Lutembacher's disease, and in several of the cases of anomalous chambers.

It would thus appear to be one of the most common congenital defects. Excluding those cases complicated by other defects, autopsy was performed in only one case. This would lead to the conclusion either that the diagnosis was incorrect, or that children do not often die of uncomplicated pulmonary stenosis.

In the uncomplicated cases, the diagnosis was made usually by the clinician and not the roentgenologist. In 29 cases diagnosed clinically, 11 were confirmed by roentgen examination, 11 were thought to be normal and 8 abnormal, but no specific diagnosis could be made.

In all of the cases of the tetralogy of Fallot, the characteristic concave depression in the region of the pulmonary conus caused by pulmonary stenosis was readily recognized.

This was seen in only 8 of the 29 cases diagnosed clinically as pulmonary stenosis alone. The following case is a good example of one of these:

Case VIII (Fig. 8). W. B., white male, aged thirteen months. Admitted to the Hospital on June 29, 1940, with a history of having been ill for four weeks with an upper respiratory infection. For the last few days, respirations were so labored that admission to the hospital was advised.

There was a discharge from both nostrils and the pharynx was inflamed. The chest showed impairment of percussion note over the left lower lobe, also fine crepitant râles.

Roentgen examination showed marked enlargement of the right side of the heart. The shadow of the ascending aorta was extremely narrow. The shape of the heart suggested patent foramen ovale. The lungs were clear.

The child was put on sulfapyridine for pneumonia, and at the end of two days his temperature was normal.

The child was discharged with a diagnosis of bronchopneumonia; catarrhal otitis media; congenital heart disease.

Complete atresia of the pulmonary artery was seen in 2 cases of tetralogy of Fallot, constriction of the pulmonary conus in one.

Valvular pulmonary stenosis was not mentioned specifically in any clinical diagnosis, although that may have been the type of stenosis the clinician had in mind. It was not recognized at all on the roentgenogram.

AORTIC STENOSIS

This term is used here to include stenotic lesions of the aortic valve, constriction in the region of the aortic conus and in the aorta itself, usually just beyond the arch. Complete obliteration of a portion of the aorta, aortic atresia, is also included.

In valvular stenosis the cusps are thickened and rigid; they may be fused, probably from fetal endocarditis. A fourth cusp is sometimes present and fused with another cusp, thus causing stenosis. A bicuspid aortic valve usually undergoes sclerotic changes with subsequent bacterial infection. The left ventricle becomes hypertrophied. The aorta is rather small. There is a systolic murmur accompanied by a thrill. The aortic second sound is diminished. The blood pressure is low, the pulse is small, and the patient is apt to be poorly developed and anemic from poor circulation. Dissecting aneurysm of the ascending aorta and aneurysm of the sinus of Valsalva have been reported as complications of this lesion.

Subaortic stenosis is a term applied to a narrowing of the left ventricle immediately below the aortic cusps. It usually takes the form of a fibrous collar encircling the aortic conus which has a tendency to become calcified. The clinical picture and the roentgen findings are the same as in valvular stenosis.

Aortic stenosis, or coarctation of the aorta, is a narrowing of the lumen which is usually located just distal to the left subclavian vein and consequently in the region of the ductus arteriosus, most often just below it. In a great majority of cases the ductus is closed. However, there are a number of variations, the chief of which are as follows:

1. Stenosis of arch, ductus arteriosus patent.
2. Stenosis of arch, ductus arteriosus closed.
3. Complete atresia of arch, ductus arteriosus closed.
4. Interruption of arch, ductus arteriosus patent.
5. Absence of ascending aorta, ductus arteriosus patent.

The narrowing is usually just below the left subclavian, and may be visualized on roentgen examination, but it is not often possible to do so. The ascending aorta becomes quite dilated, part of the blood which should go into the descending aorta is forced through the anastomotic collateral circulation, largely the intercostal arteries. The dilated intercostals wear a groove on the under surface of the ribs, best seen from the third to the ninth, and about 2 or 3 inches from the spine. The recognition of these notches is the most reliable roentgen sign, combined with a dilatation of the ascending aorta. The left ventricle also hypertrophies to overcome the increased resistance in the aorta; and in the later stages when the aortic valve becomes incompetent, there is a gross enlargement of the entire heart.

Because of the increased amount of blood in the upper part of the body, there may be throbbing in the neck, fullness in the head, epistaxis, enlarged thyroid, the hands are warm and moist, the pulse in the wrist is full and bounding. In contrast to this, the deficient circulation in the lower part of the body causes numbness and cold feet, and the tibial pulse is weak or absent. This clinical syndrome is so constant and characteristic as to be diagnostic, even in the absence of roentgenologic confirmation. The only roentgen finding which is peculiar to this lesion is the groove on the under surface of the ribs, and this sign is absent if the ductus arteriosus is patent. It requires some time for the anastomotic vessels to dilate sufficiently to produce the groove on the ribs. Some authorities say it cannot be recognized in a child under six years of age. A considerable percentage of cases die during infancy. If they survive until collateral circulation is established they usually reach early middle life and die of cardiac failure. Dissecting aneurysm of the ascending aorta has been reported, also rupture of the auricle.

The most common congenital anomalies occurring in combination with coarctation of the aorta are bicuspid aortic valves, sub-

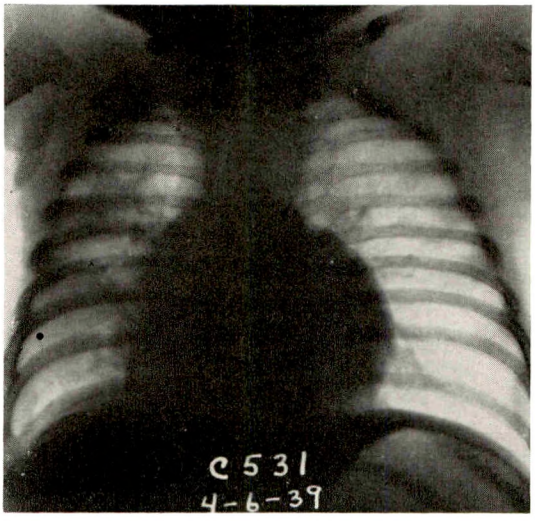


Fig. 9. Case ix. Probable aortic stenosis. The heart is generally enlarged, being globular in shape. The shadow of the ascending aorta is extremely narrowed.

aortic stensosis and congenital aneurysm of the sinus of Valsalva. Hypoplasia of the aorta, not strictly an aortic stenosis, may be found where there are other anomalies which prevent blood from reaching the aorta and it consequently atrophies.

Aortic Atresia. In this condition a portion of the aorta is a fibrous cord, the lumen being completely obliterated. If the interventricular septum is intact and the ductus arteriosus patent, the right chambers and the pulmonary artery are dilated, the left ventricle is aplastic. This is essentially a "cor biatriatum triloculare." Occasionally a mitral atresia accompanies an aortic atresia and under these circumstances, with the foramen ovale patent, the left auricle is also rudimentary, presenting in effect a "cor biloculare."

In aortic atresia it is necessary for the ductus arteriosus to be patent, or the patient cannot survive. The only blood which can reach the systemic circulation is from the pulmonary artery into the open ductus and thus into the aorta. Naturally cyanosis is extreme and the average duration of life is only a few days.

In our series there were 5 cases diagnosed aortic stenosis, and 5 cases diagnosed coarctation of the aorta. In 1 of those diagnosed aortic stenosis, the roentgenogram of the heart was negative. In the other 4 the appearance was quite alike. The heart was considerably enlarged, in 1 case quite globular, and the shadow of both the ascending and descending aorta was practically absent. A typical case is the following:

Case ix (Fig. 9). P. P., colored female, aged five months. Admitted to the Hospital April 5, 1939, with an abscess of the left thigh, temperature of 104° F. The abscess was incised and pus evacuated.

Roentgen examination showed an osteomyelitis of the femur. In addition to the osteomyelitis, the roentgenogram showed a moderate enlargement of the heart which was globular in shape, lying in the midline. The shadow of the aorta was not seen.

The patient developed a bronchopneumonia on April 18, 1939, at which time further roentgen examination showed a large area of consolidation in the right lung due to pneumonia. The patient died on April 25, 1939. Autopsy was not done.

Diagnosis: Probable aortic stenosis.

Contrary to our expectations, 4 of the 5 cases of coarctation had typical roentgen findings. The fifth case was complicated by a ventricular septal defect and the heart was so greatly enlarged that the shadow of the aorta was masked by the heart. This case came to autopsy. The other 4 cases whose ages were one month, one month, six months and seven months respectively, all presented a very striking appearance as if the left half of the aorta had been removed. This entire absence of the usual aortic shadow from the middle of the arch onward was identical in each. Two of these cases came to autopsy, one of which is presented here. The left ventricle was enlarged in all the cases.

Case x (Fig. 10). T. C., white male, aged six months. Admitted to the Hospital on January 7, 1938.

The child had a history of jaundice since the age of six weeks. He was fairly well nourished and did not appear acutely ill. The skin and mucous membrane were markedly jaundiced.

There was no dyspnea or cyanosis. The liver and spleen were somewhat enlarged. There was a slight anemia and slight leukocytosis.

At the end of three days, his temperature rose to 104° F. and examination showed the presence of a pneumonia. A roentgenogram of the chest showed a bronchopneumonia in the middle of the right lung, the right heart was dilated and the arch of the aorta was smaller than normal. The possibility of a congenital aortic stenosis was suggested. The child died on January 14, 1938.

At autopsy, the ductus arteriosus was found to be patent, although the lumen was small. The aorta in the region of the arch was slightly smaller than the ascending portion. The foramen ovale was patent. The valves were normal.

Diagnosis: Patent ductus arteriosus; patent foramen ovale; coarctation of aorta.

I have seen 2 cases of coarctation of the aorta in adults, but obviously the narrowing in the aorta could not have been nearly as great as in the case of the infants described above. As a matter of fact, the narrowing could not be seen in either of the adult cases. One of these, a boy aged sixteen, was being examined for insurance. There were no symptoms relative to this condition except dyspnea on exertion. Clinically, the pulse in the lower extremities was almost absent, the blood pressure in the arms was 164/90, and 90/60 in the legs. There was a systolic murmur at the apex. Roentgen examination showed a slight enlargement of the heart, a dilated ascending aorta and the characteristic notching on the under surface of the ribs close to the spine which is caused by erosion from the dilated intercostal arteries.

The other adult case was a man aged twenty-six, who had been told he had a congenital heart lesion and who entered the hospital for an operation for anal fistula. He exhibited marked engorgement of the vessels of the neck and chest, blood pressure in the arms was 240 and in the legs 140. A roentgenogram of the chest showed a tremendous enlargement of the heart, but no constriction in the aorta could be demonstrated. There was some notching on the under surface of the ribs. Coarctation of the aorta with failing compensation of the heart seemed obvious.

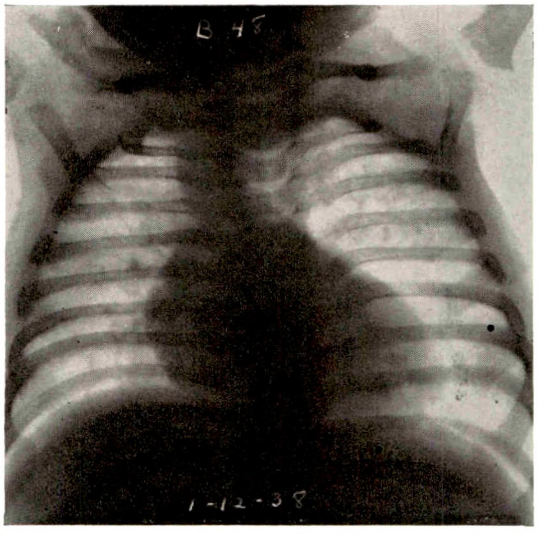


Fig. 10. Case x. Patent foramen ovale. Patent ductus arteriosus. Coarctation of aorta. Note the hypertrophy of the left ventricle and the absence of the aortic shadow beyond the arch.

I cite these 2 cases to emphasize the difference between the findings in this disease in infancy and in adult life. It seems certain none of the infants reported here will reach adult life.

One case of atresia of the aorta was present in this series. The obstruction in the aorta was just beyond the valves, the lumen being about 1 mm. in diameter. It was accompanied by defects in both the auricular and ventricular septa, and this probably altered the appearance of the heart. There was enlargement of both the right and left sides of the heart, but curiously enough the shadow of the great vessels was not appreciably altered from the normal. Life, of course, is very short in cases of this sort. A brief description of this case follows.

Case xi (Fig. 11). Baby W., white female, born March 28, 1938. This infant was cyanotic from birth. There was a loud systolic murmur over the entire precordium.

Roentgen examination made March 29 showed enlargement of the heart. The shadow suggested an interauricular defect. The infant died the following day.

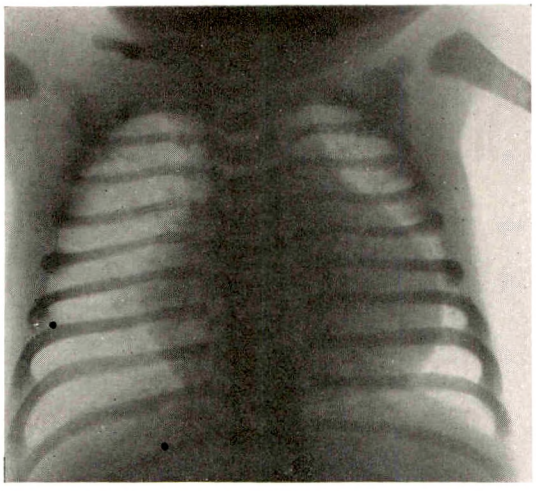


FIG. 11. Case XI. Atresia of aorta. Defects in both septa. Patent ductus arteriosus. The heart is generally enlarged, being globular in shape. The shadow of the ascending aorta is absent.

Autopsy showed enlargement of the heart which lay transversely. The left ventricle was exceedingly small. The left auricle also was small, being nothing but a tiny appendage. The tricuspid and pulmonic valves were normal. The aorta was extremely stenotic, permitting only a fine wire to be passed. The lumen was estimated to be not more than 1 mm. in diameter. There was an opening 3 mm. in diameter in the interventricular septum. The foramen ovale was patent. The arch of the aorta was very narrow. The descending aorta was normal. The pulmonary artery was about twice normal size. The ductus arteriosus was patent and quite large.

Diagnosis: Aortic atresia; defects in both septa; patent ductus arteriosus.

TRANSPOSITION OF GREAT TRUNKS

In complete transposition of the great trunks the aorta arises from the right ventricle, the pulmonary artery from the left ventricle. If there are no other defects, life must be extremely brief as there is no way for oxygenated blood to reach the systemic circulation.

The most common complication is a defect of the interventricular septum which allows a certain amount of mixing of blood in the two ventricles and at least permits life for a time.

A patent foramen ovale accomplishes the same purpose as does a patent ductus arteriosus. In this situation the larger the defect the better. The right heart becomes greatly enlarged in complete transposition and with the marked dilatation of the great vessels which is also present, the heart assumes a globular shape. There is a marked cyanosis unless there are other defects as mentioned above when the cyanosis is moderate.

In partial transposition the aorta and pulmonary artery arise from the same ventricle.

In corrected transposition, while the location of the aorta and pulmonary artery is reversed, each arises from its proper ventricle.

In the only case which has come under our observation, there was an accompanying patent foramen ovale and patent ductus arteriosus. This allowed a certain amount of oxygenation, but the baby was cyanotic from birth. Roentgen examination showed a very marked enlargement of the right side of the heart which naturally would follow in either of these defects. The general effect was a more or less globular shape which, together with the marked cyanosis, should have suggested the diagnosis. The exact nature of the defects, however, was not recognized until the case came to autopsy at the end of nineteen days.

CASE XII (Fig. 12). Baby M., born April 14, 1936, by cesarean section. Soon after birth the baby began having attacks of cyanosis. On April 16, respirations were 88, pulse 160. The breath sounds were normal. The child was blue. There was a systolic murmur to the left in the pulmonic area.

Roentgenogram made on April 25 showed a marked enlargement of the right side of the heart. Another roentgenogram made later showed the heart to be more distended than before. The cyanosis increased and the baby died on May 3.

At autopsy the aorta was seen arising from the right ventricle and pursued the usual course. The pulmonary artery arose from the left ven-

tricle and pursued its usual course, giving off a right and a left branch. The ductus arteriosus was patent. The foramen ovale was open. The heart was otherwise normal.

Diagnosis: Transposition of great trunks; patent ductus arteriosus; patent foramen ovale.

PERSISTENT RIGHT AORTIC ARCH

In early embryological life there are six pairs of aortic arches. Of these, the first, second and fifth pair disappear entirely. The third pair become the internal carotid arteries. The fourth right arch becomes the innominate artery and right subclavian. The fourth left arch becomes the arch of the aorta. The sixth pair become the pulmonary artery and ductus arteriosus.

If the fourth left arch becomes stenotic during fetal life, the result is coarctation of the aorta; or if the lumen is completely obliterated, the right arch takes its place, producing the anomaly under discussion. If the left arch persists partly and the right also persists, the left root causes a rounded projection similar to the normal aortic knob and confuses the diagnosis.

If both right and left arches persist, the ascending aorta divides and one branch goes behind the trachea and esophagus, while the other goes in front, thus completely encircling the structures with a vascular ring. The two branches meet again posteriorly and merge into the descending aorta. This anomaly is of clinical significance since the pressure of the aorta on the esophagus causes dysphagia in later life when degenerative vascular changes begin to appear.

In this anomaly, roentgen examination of the esophagus with a barium meal shows a round defect on the posterior surface of the esophagus where it is compressed by the aorta.

In persistent right aorta, the ascending aorta occupies its usual position, or it may be displaced somewhat to the right. The aortic arch extends backward instead of to the left and the usual aortic knob on the left side is absent. The descending aorta goes downward to the right of the spine.

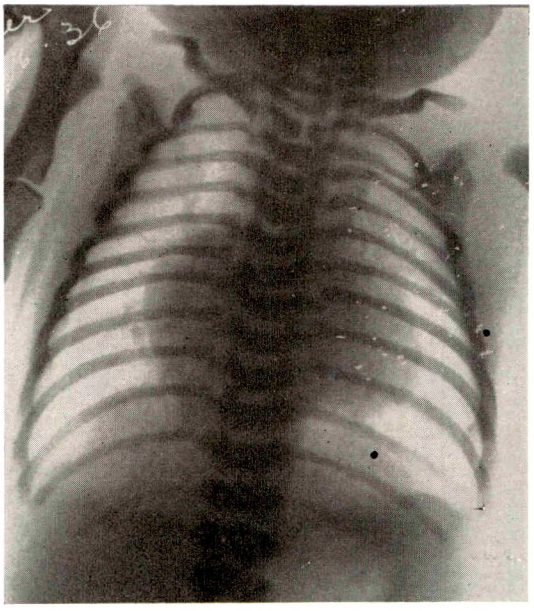


Fig. 12. Case xii. Transposition of great trunks. Patent foramen ovale. Patent ductus arteriosus. The right heart is more enlarged than the left, but there is nothing characteristic in the shape of the heart which would suggest the transposition.

The trachea is displaced to the left by the descending aorta and if a barium meal is given under the roentgenoscope, the esophagus will be found displaced to the left and also anteriorly. The appearance on the roentgenogram, as well as the displacement of the esophagus as revealed with the barium meal, are quite characteristic and should make the diagnosis. This anomaly alone does not shorten life.

Three cases of persistent right arch have occurred in our series. The roentgen appearance is quite characteristic. The ascending aorta is definitely larger than normal and also bulges more to the right than is usual. The aortic knob is at the upper end of the ascending aorta and projects to the right instead of to the left. There is no shadow of the aortic knob in its normal location and no descending aorta. The appearance is somewhat similar to that seen in the cases of coarctation reported elsewhere in this article except that in coarctation the aorta looks as if the left half had been cut away with a knife, but in

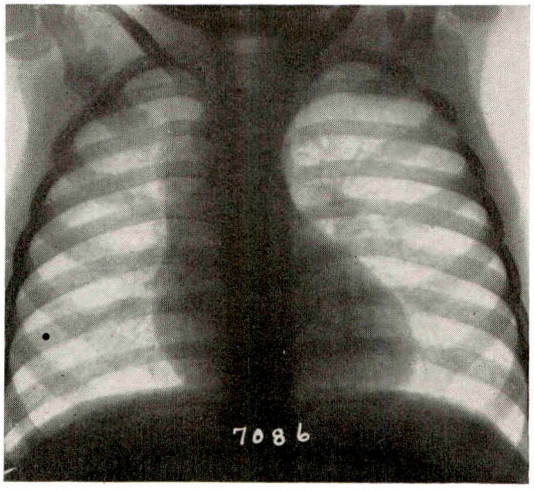


FIG. 13. Case XIII. Persistent right arch of aorta. Persistent truncus arteriosus. Defects in both septa. The absence of the aortic knob in its usual position on the left side and the bulging of the aorta to the right are indicative of persistent right arch.

persistent right arch the impression is that of the entire aorta being displaced toward the right. The case reported below also presented other anomalies, but the appearance of the aorta is identical with that seen in the other two cases.

CASE XIII (Fig. 13). G. C., white female, aged two and one-half. Admitted February 24, 1933. The child was undernourished; lips and finger nails were cyanotic; tonsils were large. There was a loud systolic murmur at the apex transmitted to the vessels of the neck; also a systolic murmur in the aortic region. Patient was discharged with a diagnosis of congenital heart disease.

She was seen a year later at which time the conditions were about the same.

She was readmitted May 8, 1937, with an otitis media. At this time there was some bulging in the precordial region. Otherwise, the heart examination was the same as before. A diagnosis of interventricular septal defect was made at this time.

She was readmitted on February 11, 1939, because of an acute illness accompanied by cough, fever and extreme cyanosis. Roentgen examination of the chest showed an enlargement of the heart in the region of the left ventricle. The right auricle also was enlarged. There was a large protruding shadow in the region of the ascending aorta.

The child died on February 25, 1939.

At autopsy, the heart was markedly enlarged, particularly the right side. The foramen ovale was patent and measured 8 mm. in diameter. The wall of the right ventricle was 1.3 cm. thick. There was a defect measuring 1.5 cm. in the interventricular septum. The mitral and bicuspid valves both showed numerous vegetations. There was a persistent truncus arteriosus which straddled the septum. The great vessels arose from their usual position, but the pulmonary artery was given off distal to the base of the arch. The arch of the aorta did not extend to the left, but turned posteriorly and went down to the right side of the vertebral column.

Diagnosis: Patent foramen ovale; patent interventricular septum; persistent truncus arteriosus; persistent right arch of aorta; vegetative endocarditis.

ANOMALIES OF AORTIC SEPTUM

The aorta and pulmonary artery develop from a common trunk by the growth of a septum which extends lengthwise of the vessel and separates it into two parts. If this septum does not develop, the condition resulting is a persistent truncus arteriosus. The septum may be perforated, producing defects of the aortic septum. If the septum develops far over toward the pulmonary artery side, the result is a stenosis or atresia of the pulmonary artery. If it encroaches on the aortic side, we have aortic stenosis or atresia. The two latter conditions are discussed elsewhere in this article.

Persistent Truncus Arteriosus. In this condition only one great trunk arises from the heart, the pulmonary artery being absent. A right and left pulmonary artery are given off the aorta at some distance above the valves and the blood reaches the lungs through these. The truncus arteriosus arises either from the right ventricle or astride the ventricular septal defect which is always present. The only path for blood to leave the heart is through this trunk which is continuous with the remainder of the aorta. There is, of course, a free admixture of arterial and venous blood, but partial oxygenation can take place and life

may be prolonged into adolescence. The heart is enlarged both to right and left. Cyanosis is marked.

Other congenital anomalies which have been reported in combination with this are patent interauricular septum and persistent right arch of aorta.

Defects of the aortic septum are usually found in the right aortic sinus of Valsalva and lead into the pulmonary conus. The result, of course, is a communication between the aorta and the pulmonary artery through which the blood passes from left to right. Because the flow is in this direction, cyanosis is absent. The pulmonary artery becomes much dilated as in patent ductus arteriosus which it greatly resembles, both in the result brought about by the shunt and in the clinical and roentgen signs. The heart becomes enlarged generally; there is a continuous murmur because the blood flows continuously through the abnormal opening. Infective endocarditis is a common complication and the average age at death is fourteen years. There were no examples of this defect in any of our cases which came to autopsy and it was not recognized in any other.

Persistent truncus arteriosus occurred a number of times, always in connection with a ventricular septal defect. It was common in our cases of the tetralogy of Fallot. In most of our cases the pulmonary artery arose from the aorta just beyond the left subclavian artery, but in one case it arose just beyond the pericardium.

The diagnosis of persistent truncus arteriosus is probably not possible in life. By roentgen examination it cannot be differentiated from a dextroposed aorta with pulmonary stenosis which is the usual combination in the tetralogy of Fallot.

Persistent truncus arteriosus was present in Cases II, XIII, XIX and XXI.

ANOMALOUS CHAMBERS

Cor Biventriculare Triloculare. In this condition the septum between the auricles is absent. If there are no other anomalies, cyanosis is slight until the terminal stages. However, other cardiac anomalies are frequently present. The most common are anomalies of the pulmonary veins, or of the vena cava. Dextrocardia, transposition of vessels and defect in the interventricular septum have all been reported as complications of this defect. Death occurs from cardiac failure.

In the 3 cases which have occurred in our experience the roentgen appearance was not characteristic. In one of these the right ventricle was so rudimentary that it was practically functionless. This was evidently due to a combination of pulmonary stenosis and ventricular defect which was present, in addition to the absence of the interauricular septum. In the other 2 cases the shape of the heart was quite different; in one the heart being very large apparently because of insufficiency of the mitral valve; in the other, a very large defect in the interventricular septum altered the shape. Apparently the appearance in this anomaly is controlled largely by the accompanying defects.

Case XIV (Fig. 14). J. S., white male, aged five months. Admitted to the Hospital May 13, 1939, because of cyanotic spells which were first noticed when the baby was six weeks old. At first these were of short duration, but for the past two months the child was cyanotic most of the time.

He was dusky over the entire body, the color varying from light blue to deep purple. He was listless and apathetic. He appeared acutely ill.

The heart was somewhat enlarged to the right on percussion. There was a systolic murmur heard over the left base. The liver was somewhat enlarged.

The roentgen examination of the chest showed an increase in the size of both the heart and the aorta. A second examination made about one week later showed an increase in the size of the heart.

The patient was placed in an oxygen tent and and given coramine. He improved somewhat and was discharged from the Hospital on June 4, 1939, with a diagnosis of congenital heart disease.

He was readmitted on September 1, 1939, with marked cyanosis, labored respiration,

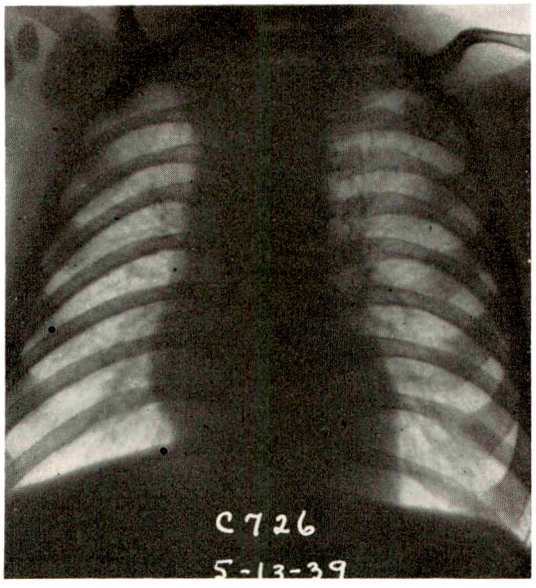


FIG. 14. Case XIV. One auricle; two ventricles, the right rudimentary. Defect in interventricular septum. Pulmonary stenosis. These lesions probably could not be diagnosed from the roentgenogram, but the small size of the right ventricle is evident and the normal shadow of the pulmonary conus is absent.

temperature of 104° F. A diagnosis of pneumonia was made. The child became progressively worse and died on September 5.

Autopsy: The heart was about twice normal size. It lay in almost transverse position, the right lateral border on the diaphragm. There was no septum between the right and left auricles, the vena cava and pulmonary veins both emptying into the same cavity. There was only one auriculoventricular orifice and this had five leaflets. It was somewhat to the left and opened into the left ventricle. There was a small opening 3 mm. in diameter in the interventricular septum. The aorta arose from the left ventricle to the left of the ventricular septum. The aorta was some what dilated and ran a normal course. The ductus arteriosus was absent. The right ventricle was extremely rudimentary and consisted only of a potential cavity in the right wall of the left ventricle. It opened into the left ventricle by a small defect. The pulmonary artery arose from the right ventricle to the left of the aorta. It was stenotic, measuring 2 cm. in circumference at the pulmonic valve. The pulmonic valve had only two cusps. The remaining course of the pulmonary artery was normal.

Diagnosis: Cor biventriculare triloculare; defect in interventricular septum; pulmonary stenosis.

Cor Biatriatum Triloculare. A right and left auricle open into one ventricle from which both the aorta and the pulmonary artery arise. A more frequent deformity which is really not a three-chambered heart occurs in the presence of atresia of the mitral valve where the left ventricle is so small as hardly to be recognizable. The aorta arises from the rudimentary left ventricle in this case, but is also hypoplastic and unless the ductus arteriosus is patent life is very brief.

In true cor biatriatum triloculare, both the aorta and the pulmonary artery arise from a common ventricle in which there is a free admixture of arterial and venous blood. However, there is not a great deal of cyanosis as most of the venous blood goes into the pulmonary artery and most of the arterial into the aorta because the respective location of these trunks favors flow in that direction. The heart is quite large and the shadow of the great vessels smaller than normal. The right ventricle is particularly large and the pulmonary artery small. These cases may live to adult life. The oldest age at death reported is thirty-five years.

We have had 4 cases presenting this defect. One of these was evidently due to an absence of the ventricular septum, but the other 3 were secondary to an atresia of the aorta or pulmonary artery which made the respective ventricle useless and consequently rudimentary. There was nothing characteristic in the shape of the heart in any of the cases. The case reported below was due to absence of the interventricular septum.

CASE XV (Fig. 15). J. H., white male, aged one month. Admitted to the Hospital October 26, 1935, because of feeding difficulty and also because he had attacks in which he became blue.

The child has had cyanosis and shortness of breath since birth. He seemed undernourished,

had cyanosis of the lips, fingers and toe nails, and duskiness of the skin. The heart was enlarged downward; impulse at the costal angle. The heart sounds were booming. There was a loud systolic murmur at the apex. Pulse rate was about 150.

On October 28, 1935, roentgenograms of the chest showed enlargement of the heart, and areas of consolidation in the right upper lobe, thought to be due to pneumonia. The child was placed in an oxygen tent, but died the next day.

Autopsy of the heart showed a patent ductus arteriosus, the lumen being about 6 mm. in diameter. There was an enormously dilated right auricle, a small left auricle and one ventricle which was conical in outline. The pulmonic and aortic valves were normal. The tricuspid valve was normal. There was no mitral valve. The left auricle was open and found to be a small blind pouch through which the blood flowed to the right auricle through a patent foramen ovale.

Diagnosis: Cor biatriatum triloculare; patent ductus arteriosus.

Cor Biloculare. Complete absence of both auricular and ventricular septa is very rare and is usually associated with other anomalies. The condition is most serious. Profound cyanosis is present at birth and life is very brief. The one case which has occurred in our experience died at the end of twenty-three days. The heart was extremely enlarged in this case and more or less globular in shape. It was obvious that a serious anomaly was present, but differentiation was not possible until the case came to autopsy.

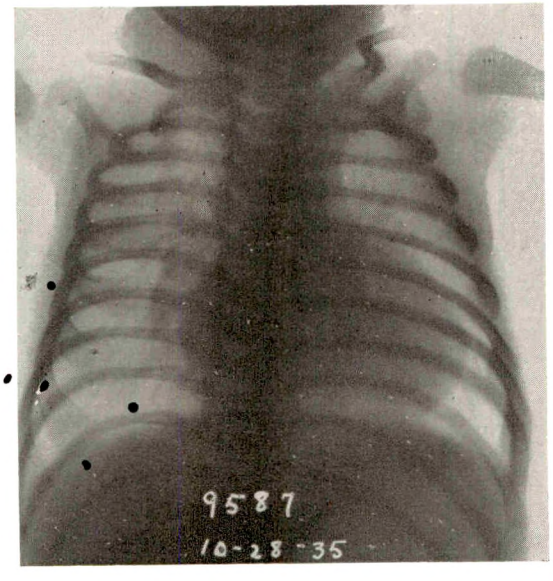


Fig. 15. Case xv. Cor biatriatum triloculare. Patent ductus arteriosus. See text for description of heart at autopsy.

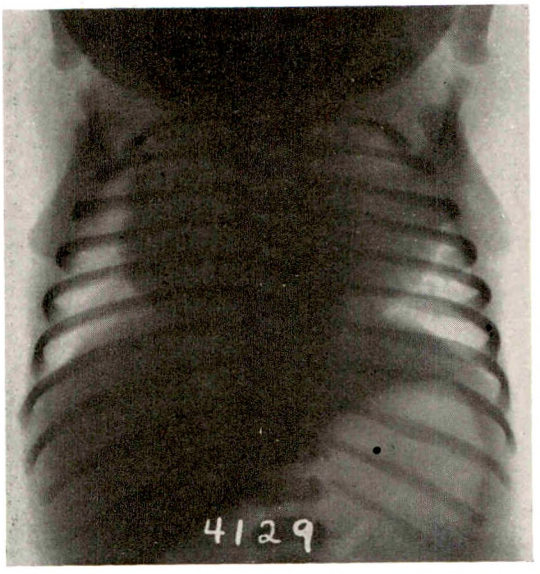


Fig. 16. Case xvi. Cor biloculare. Patent ductus arteriosus. Patent foramen ovale. Atresia of pulmonary artery. Diagnosis of congenital heart disease was obvious in this case, but the exact nature of the lesion was not known until autopsy.

Case xvi (Fig. 16). Baby L., colored female, born December 25, 1939.

This child was cyanotic and extremely dyspneic from birth. A roentgenogram showed a marked enlargement of the supracardiac shadow, and the heart also was much enlarged and globular in shape. The child died at the end of twenty-three days.

At autopsy a very large heart was found which almost hid the lungs from view. The aortic arch was normal. There was a patent ductus arteriosus. The right ventricle was large. The pulmonary artery was obliterated from the heart to the ductus arteriosus. The right auricle was very large. There was a patent foramen ovale which opened into a tiny left auricle. The left ventricle was a mere slit which was separated from the right ventricle by a hypertrophied papillary muscle, through which communication could be established. There

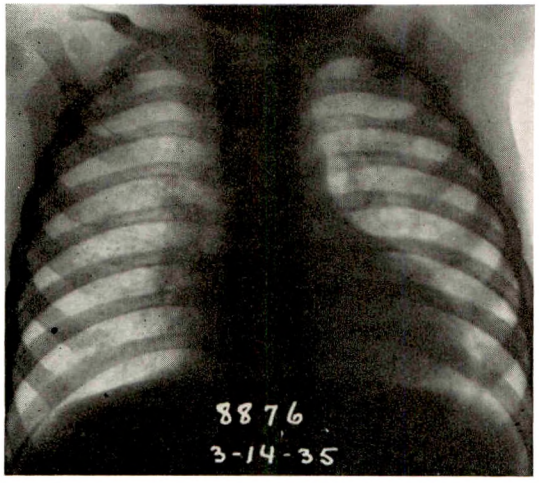


Fig. 17. Case xvii. Tricuspid stenosis. Patent foramen ovale. There is a marked enlargement of the left ventricle, and a concavity instead of a convexity in the region of the pulmonary conus.

was practically no identifiable left auricle or ventricle.

Diagnosis: Cor biloculare; patent ductus arteriosus; patent foramen ovale; atresia of pulmonary artery.

CONGENITAL VALVULAR LESIONS

These lesions may be developmental, or the result of infection in utero. There is a difference of opinion regarding fetal endocarditis, some authorities believing it does not occur. Be that as it may, the actual pathology is a deformity, thickening or adhesions of cusps which interfere with proper action. Sometimes there are only two cusps where there should be three, or there may be supernumerary cusps. Of itself the number of cusps is not significant, but the bicuspid valve may be incompetent, or the supernumerary cusp may adhere to another and cause either stenosis or insufficiency.

Tricuspid stenosis is often associated with pulmonary stenosis; aortic and mitral stenosis occur together.

Tricuspid stenosis results in a dilatation of the right auricle; the right ventricle is very small. If there is a defect in the ventricular septum the left ventricle hypertrophies, the aorta is widened and the normal pulmonary arc is absent. If the stenosis is very marked the right ventricle is rudimentary, producing one form of cor biatriatum triloculare. Cyanosis is very marked. Roentgen examination shows a rather globular-shaped heart, the right auricle and the left ventricle being particularly enlarged.

Only one case of this defect occurred in our series. The anomaly was a developmental defect, there being only one cusp which was attached in such a way as to produce marked stenosis. While diagnosis from the roentgenogram would perhaps not be justifiable, there is a definite enlargement of the left ventricle and the area of the pulmonary conus is concave instead of convex. The defect was not recognized until autopsy, although it should probably have been suspected from the roentgenogram.

Case xvii (Fig. 17). C. O., white male, aged one year. Admitted to the Hospital on December 26, 1934, because of fever and restlessness. This was found to be due to a suppurative otitis media. Signs of meningitis developed. The baby finally improved and was discharged on January 21, 1935. At the time of admission there was a marked systolic murmur over the entire chest, but loudest over the base.

The child was readmitted on February 25, 1935, because of fever and difficulty in feeding. An otitis media was found on the right side. There were a few râles in the chest. The heart murmur seemed louder than on the previous admission. The child was discharged on March 7, 1935.

He was readmitted on July 29, 1935, in a stuporous condition, with continuous clonic convulsions. The head turned to the left and a left nystagmus noted. Râles were heard throughout the chest. The heart was very rapid and a loud systolic murmur noted over the pulmonic area. A diagnosis of bronchopneumonia with possible meningitis was made. The child died on July 29, 1935.

Autopsy: The right side of the heart was markedly dilated. The wall of the right auricle and ventricle were distinctly hypertrophied. The tricuspid valve had only one cusp and it was attached in such a way as to allow only a very small orifice. The foramen ovale was patent, but otherwise the heart and great vessels were normal.

Diagnosis: Tricuspid stenosis; patent foramen ovale.

Tricuspid insufficiency is usually due to developmental defects in the cusps, either as to number or shape. The right auricle becomes much dilated, the right ventricle is also somewhat larger than normal. Patent foramen ovale may be present, but other anomalies are rare. Cyanosis varies, but is apt to be marked and the lesion may be serious. The heart becomes generally enlarged, there is a loud systolic murmur in the third and fourth interspaces close to the sternum. A thrill may be present. In late stages the veins of the neck become distended, the liver enlarges and there is passive congestion of the viscera.

In this series of cases there was one (Case XXI) in which neither mitral nor tricuspid orifices had any valves whatever. This might perhaps be classified as a case of insufficiency. There were so many other defects present that any valvular lesion could hardly have been recognized.

Mitral Stenosis. According to Abbott this lesion is very rare. If present it is developmental in character. The left heart and aorta are hypoplastic, the ductus arteriosus is usually patent, and often the foramen ovale. The right heart is enlarged, the left ventricle may be a mere slit, thus producing the other form of cor biatriatum triloculare. Life is extremely short in this lesion and probably diagnosis can be made only at autopsy.

Mitral stenosis was diagnosed in 3 cases of this series. The stenosis was due to thickening and fibrosis of the cusps. In 1 case which came to autopsy the heart was extremely dilated, but as there was also a defect in both septa and a patent ductus arteriosus, it is difficult to estimate what part of the deformity was due to the mitral stenosis.

Case XVIII (Fig. 18). C. B., white male, aged twelve weeks. Admitted to the Hospital June 5, 1934.

When this baby was three weeks of age, it had extreme difficulty in breathing. A roentgenogram was made and a diagnosis of enlarged thymus made. Roentgen treatment was given, but without any improvement in the baby's condition. The difficulty in breathing and the cyanosis have continued up to the time of admission.

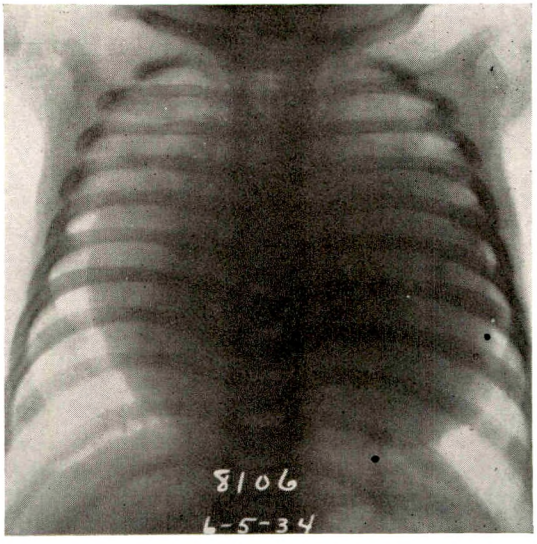


Fig. 18. Case XVIII. Defects in both septa. Patent ductus arteriosus. Mitral stenosis. While it was obvious this child had congenital heart disease, the exact nature of the defects could not be estimated because of the extreme dilatation of the heart.

There was a bulging of the upper part of the chest and marked indrawing of the epigastrium on inspiration. Examination of the heart showed marked enlargement, with tachycardia, but no murmurs, no thrill.

Roentgen examination revealed an enormously dilated heart. The diagnosis of enlarged thymus was not substantiated.

The baby died on June 6, 1934.

Autopsy: Both auricles were very large. The ventricles were not increased in size. The left seemed somewhat smaller than normal. The ductus arteriosus was patent. There was a very large defect in the ventricular septum. There was a large opening in the interauricular septum above the foramen ovale. The mitral valve was somewhat stenotic. It would not admit the tip of the little finger. The thymus was somewhat enlarged, weighing 17 grams.

Diagnosis: Defect in both septa; patent ductus arteriosus; mitral stenosis.

In another case reported below (Case XX), the left ventricle was markedly en-

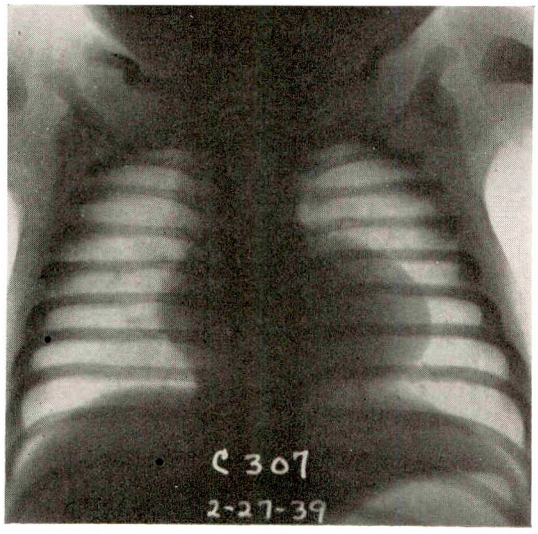


Fig. 19. Case xix. In this case the left auricle did not connect with any other chamber of the heart. There was an interventricular defect which produced the characteristic wooden shoe shape seen. There was a persistent truncus arteriosus which was dextroposed and seen somewhat to the right of the usual location of the ascending aorta.

larged which is a little difficult to understand as this is not the change one would expect to find in this defect. Two cases which came to autopsy had no mitral orifice whatever. One of these is illustrated in Case xix.

Case xix (Fig. 19). F. G., white female, aged eight days. Admitted to the Hospital February 25, 1939, because of a mild degree of cyanosis and inability to get the child to take food. Cyanosis was more marked when the baby cried.

Respirations were normal. The heart was slightly enlarged to the left. There was a soft systolic murmur at the apex.

Roentgen examination of the chest showed a marked enlargement of the right side of the heart and the apex was displaced upward. The shape of the heart suggested patent interventricular septum.

The cardiologist examined the heart and reported a slight enlargement of the heart, with a soft systolic murmur over the base and diffuse cyanosis. His diagnosis was congenital heart disease, probably patent foramen ovale.

The child was readmitted on March 9, 1939, with the same symptoms, only much worse. Breathing was very difficult and the child very cyanotic. She was placed in an oxygen tent. She died the next day.

Autopsy: The heart was enlarged, particularly the right side which showed dilatation and hypertrophy. The right ventricular wall was almost as thick as the left. There was a defect in the interventricular septum, the upper third being missing. Immediately above the septal defect arose a persistent truncus arteriosus. A small pulmonary artery was given off just beyond the pericardium. The remainder of the aorta was normal. There was complete atresia of the left auricle which did not communicate with the other chambers of the heart. The pulmonary veins emptied into the right auricle.

Diagnosis: Cor biventriculare; persistent truncus arteriosus; defect of interventricular septum.

A case of mitral stenosis is reported below.

Case xx (Fig. 20). J. C., white male, aged two. Admitted to the Hospital on August 19, 1935.

The patient was poorly nourished; had marked pallor. He was not acutely ill. He had some clubbing of the fingers. The lungs were clear. The heart was enlarged to the left. There was a blowing systolic murmur over the entire precordium. The second pulmonic sound was accentuated. There was a thrill over the precordium. There was no history of rheumatic

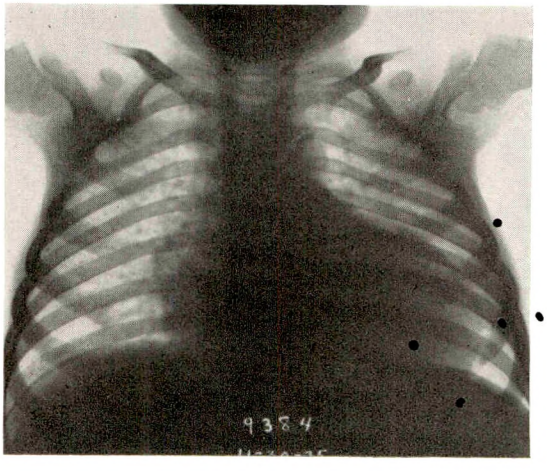


Fig. 20. Case xx. Mitral stenosis with thickening and fibrosis of the cusps. Marked hypertrophy of the left ventricle probably due to increased effort to supply enough blood to the systemic circulation.

fever. A large mass occupied the right side of the abdomen which, after investigation, was diagnosed hypernephroma. Patient was discharged on September 16, 1935.

He returned for roentgen treatment over the kidney tumor.

He was readmitted on November 29, 1935, because of a general deterioration in his condition. A roentgenogram made of his chest showed a marked enlargement of the entire heart and numerous areas of consolidation throughout both lungs, diagnosed pneumonia. He became steadily worse and died on December 1, 1935.

At autopsy, tumor of the kidney was found as had been anticipated. On examination of the heart, the mitral valve was thickened and fibrotic. The tricuspid valve was normal. The wall of the right ventricle was about 1.5 cm. thick. Heart was otherwise normal.

Diagnosis: Mitral stenosis.

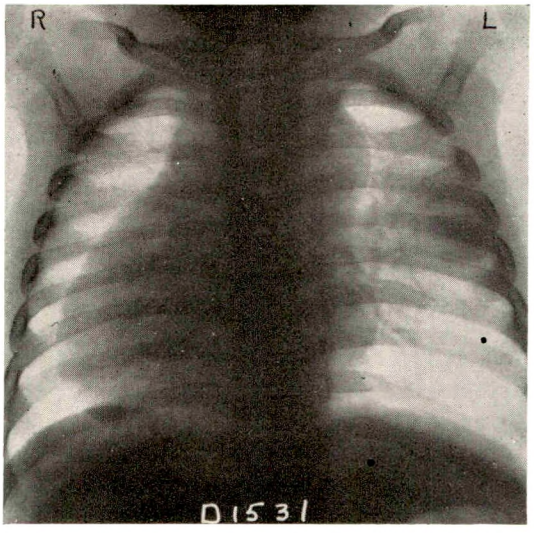


Fig. 21. Case xxi. Dextrocardia. Two auricles, one ventricle. Persistent truncus arteriosus. Atresia of pulmonary artery. Stenosis of aorta. See text for autopsy description.

DEXTROCARDIA

If dextrocardia occurs as a part of a general situs inversus, it has no clinical significance. When it occurs otherwise it is always complicated by other cardiac anomalies, according to Roesler.

We apparently have an exception to this rule in one case which was not accompanied by transposition of other organs and in which no cardiac defect could be demonstrated. The case was followed for thirteen months and presented no symptoms of cardiac disturbance during this period. There may, of course, be some anomaly not yet discovered.

The case presented below had a number of anomalies. The persistent right arch was recognized ante mortem, but the entire list of anomalies was not appreciated until the case came to autopsy.

Case xxi (Fig. 21). L. B., colored female, aged seven months. Admitted to the Hospital on December 6, 1940.

The child has had a discharging ear for the past four months and frequent head colds. On November 30, she developed a heavy chest cold with a cough. When admitted, she had difficulty in breathing and a high fever.

Examination of the chest showed numerous râles, but a definite diagnosis of pneumonia could not be made. The heart was much enlarged. The heart sounds were loud and heard best over the right side of the chest. No murmur was heard.

Roentgen examination revealed a dextrocardia, but no transposition of the organs as the liver was on the right side. In addition to the dextrocardia, there was an abnormal dilatation in the region of the ascending aorta, suggesting the possibility of a persistent right-sided arch which, in this case, would be a left-sided arch. There was a large area of bronchopneumonia in the middle of the left lung.

The child died on December 12, 1940.

Autopsy: When the chest was opened, the apex of the heart was on the right side. Both auricles were posterior. The heart had a globular appearance. There was only one vessel arising from the heart. This was the aorta which was widely dilated. The pulmonary artery was entirely obliterated from the heart to a point where it joined with a small vessel which arose from the arch of the aorta and which took the place of the pulmonary artery. The descending aorta was about half the size of the ascending aorta. There were two auricles and both connected with a common ventricle, and the wall of this ventricle was a rudimentary right ventricle which had failed to develop. A probe could be passed through a small opening in the ventricular septum into this space. There were no

valves at the tricuspid or mitral orifice, or at the vessel acting as a pulmonary artery.

Diagnosis: Cor biatriatum triloculare; dextrocardia; persistent truncus arteriosus; atresia of the pulmonary artery; coarctation of aorta.

CONGENITAL IDIOPATHIC HYPERTROPHY

It seems probable that this is not really an entity, but an acquired enlargement from any one of many causes. Congenital tumors of the heart are hardly idiopathic, the glycogen infiltration of heart muscle seen in small infants is probably not congenital and is definitely secondary. Likewise, the so-called beri-beri heart must be acquired.

We have recently seen an infant about two months old with a very large heart who has a congenital obstructive jaundice. One can think of many pathological processes in very young infants which might bring about enlargement of the heart.

Among the cases we have seen may be mentioned congenital stricture of the larynx in an infant one month old; congenital biliary duct anomaly in a child of ten months; erythroblastosis in a child of one year; avitaminosis in a child of two years.

In these cases there is a general enlargement of the heart, not characteristic of any particular anomaly. Murmurs are often heard, sometimes not. The diagnosis depends upon the recognition of the underlying cause. The roentgen examination is not of a great deal of help except that it rules out those anomalies which present characteristic alterations in the shape of the heart.

SUMMARY

As regards roentgen diagnosis, congenital anomalies may be divided into three classifications:

A. Those with characteristic roentgen appearance.

B. Those in which the appearance is either not characteristic, or else similar in different lesions.

C. Those in which the roentgen appearance is either normal or abnormal, but offers no help in differentiating the lesion.

Under *A* may be mentioned:

1. Defect of interventricular septum.
2. Defect of interatrial septum, including patent foramen ovale.
3. Lutembacher's disease.
4. Patent ductus arteriosus in most cases.
5. Tetralogy of Fallot.
6. Pulmonary atresia.
7. Coarctation of aorta usually.
8. Persistent right arch of aorta.
9. Dextroposed aorta.
10. Dextrocardia.

B includes the following:

1. Defects in both septa.
2. Interatrial defect combined with patent ductus arteriosus.
3. Most cases of pulmonary stenosis.
4. Aortic stenosis.
5. Tricuspid stenosis.

C includes the following:

1. Some cases of pulmonary stenosis.
2. Aortic atresia.
3. Transposition of great trunks.
4. Persistent truncus arteriosus.
5. Anomalous chambers.
6. Mitral stenosis.

VOL. 49, NO. 3

LEIOMYOSARCOMA OF THE STOMACH

REPORT OF CASE*

By CLINTON G. LYONS, M.D., *and* MARTIN SCHNEIDER, M.D.
Veterans Administration
HINES, ILLINOIS

IN THIS paper, we wish to add one more to the slowly growing number of cases of leiomyosarcoma of the stomach which have been reported in the literature. The particular interest that attaches to our case is derived from the disproportionate size and number of metastases, especially the symptom-producing ones in the thorax, as compared to the small, "silent" gastric tumor, thus demonstrating clearly one of the diagnostic difficulties that characterize this type of growth.

Chaffin[2] reviewed the subject of smooth muscle tumors of the stomach, collecting 363 case reports from the literature, dating back to Morgagni's case in 1762, and adding one of his own. Of these collected cases, 23 per cent were malignant. Seventeen additional reports of gastric myomata have since been recorded; 8 of these cases, or 47 per cent, were found to be malignant. The difference here may be attributed to better histological studies and earlier roentgenological diagnoses. Inasmuch as it is Ewing's[3] opinion that many gastric sarcomata are probably of myogenic origin, many more muscle tumors of the stomach might be added to the list.

Obviously, leiomyosarcomata of the stomach are not among the most rare of clinical entities, yet remain sorely neglected all too frequently in weighing the possibilities during differential diagnosis of neoplasms, not only of the stomach, but of almost any part of the body. This is indicated strikingly in consideration of our case, as in several of those in the literature to date. Further, there are some characteristics of gastric myomata which seem sufficiently peculiar to warrant emphasis, as will be noted in the course of this brief outline and case report. It is only by repeated clarification of such features in successive case reports that satisfactory clinical criteria for the diagnosis of any disease or disorder can be established. Thus, one of the outstanding occurrences noted in our type of case is the persistently "silent" gastric tumor, even in the presence of widespread and numerous metastases which are often the source of the patient's presenting complaints. The primary growth may remain undiagnosed until postmortem examination unless attention is focussed on it by some such dramatic crises as hemorrhage or perforation—and the latter is truly rare, only 4 having been reported. Symptoms apparently unrelated to the gastric lesion often occupy the spotlight for a long time. Two cases in point are, again, ours and Jordan's.[4] Jordan's patient presented only a severe secondary anemia for several years before hematemesis occurred suddenly and led to a roentgen diagnosis of multiple gastric tumors. Surgical exploration was resorted to, the diagnosis of benign leiomyomata was confirmed and a few of the tumors were excised. Four years later malignant change was found histologically, following repeated hemorrhage, and a total gastric resection was performed.

Ewing makes a point of the occurrence of severe hemorrhages from large myomata of the stomach, but it is the small tumors that are usually "silent" and result in puzzling cases. While gastric muscle tumors may grow to a size larger than that of any other type of stomach neoplasm, others may be so small as to show no more than a tiny crater at the site of ulceration, or per-

* Published with the permission of the Medical Director of the Veterans Administration, who assumes no responsibility for the opinions expressed or the conclusions drawn by the authors.

haps a small filling defect in the gastric mucosa, on roentgen examination, and frequently with no interruption of peristalsis. This latter finding occurs sufficiently often to warrant mention among the roentgen characteristics of the gastric myomata, either benign or malignant. At the opposite pole is the type of case exemplified by Baumgartner's,[1] the specimen in which weighed 700 grams and measured 20 by 20 by 12 centimeters.

Further difficulty in diagnosis is encountered in light of the tendency of any myoma of the stomach to grow outward (exogastric) or inward (endogastric). The former type may not be diagnosed at all during life, unless it becomes large enough to be palpable or to cause a pressure defect on the outline of the barium-filled stomach, and is then explored surgically. The endogastric type may be sessile or pedunculated, and, if the latter, may be as movable as any polypoid tumor in a hollow viscus with the possibility always present of prolapse through, or obstruction of, the pylorus. Previous investigators have pointed out that ulceration, when it occurs, is located at the dome of endogastric myomata and at the point of attachment of exogastric ones—i.e., at a site farthest from the source of blood supply at the point of contiguity of mucosa and neoplasm. On the whole, the endogastric leiomyomata are prone to cause earlier symptoms and permit earlier diagnoses than the exogastric type.

Undoubtedly, the increasing number of cases of this type diagnosed in the past fifteen years ante-mortem must be ascribed largely to improved roentgenologic studies and technique, combined with an increasing awareness of the possibility of the existence of such tumors in obscure cases and better correlation of clinical and roentgen findings. The one outstanding improvement in roentgen study which should be singled out is the more effective use of the roentgenoscopic observation of the stomach while it is palpated during ingestion of a radiopaque medium, to show not only gross defections but disturbances of the rugal pattern also. Repeatedly, clues have been adduced from such findings as (1) barium retained within an ulcer crater which in turn lies within a fairly well demarcated filling defect, interpreted as tumor, and (2) the observation of a normal peristalsis and mucosal pattern except in the immediate location of the neoplasm.

CASE REPORT

F. W. B., white male, aged forty-one, was admitted to the Edward Hines Jr. Hospital, July 2, 1940, complaining of cough, expectoration of grayish sputum, pain over the left hemithorax and loss of about 40 pounds in weight in the past three months. He dated the onset of his illness to December, 1939, when a mild cough developed with no other symptoms until March 28, 1940. At that time, his cough increased suddenly and was accompanied by sharp pain in the left chest, pleuritic in type, and by a fever. Despite bedrest, under medical supervision of his family physician for two months, his symptoms became progressively worse and he began to raise a grayish sputum and to lose weight. He was hospitalized at Receiving Hospital, Detroit, on May 25, 1940, where roentgen examination disclosed, in the left thorax, a mass, from which a punch biopsy was taken and a diagnosis of mesothelioma or mesothelial sarcoma of the pleura was made. The mass seen on the roentgenogram was in the left upper chest laterally, measured about 17 by 6 cm., and showed evidence of erosion of the left third and fourth ribs laterally. Another rounded mass, approximately 8 cm. in diameter, was seen on the roentgenogram at the base of the left chest, posterior to the heart. The patient was then transferred to this hospital.

Past and Family History. Non-contributory.

Physical Examination. Acutely ill white male, aged forty-one, lying in bed. *Head, eyes, ears, nose and throat:* essentially, no significant findings. *Neck:* no adenopathy or abnormal pulsations. *Chest:* respiratory lag on left side. Marked tenderness from second to fifth ribs, left side, about 2 inches to left of sternum. Small scar in fourth interspace, left axilla. Enlarged and tender left axillary nodes. Dullness to percussion in left chest, with diminished breath sounds, vocal sounds and tactile fremitus. *Abdomen:* soft; no masses, tenderness or rigidity were found. The liver, spleen and kidney were not

palpable. *Extremities:* entire left arm and forearm were tender and hyperesthetic. *Genitalia, anus*: normal.

Laboratory Data. Urine: straw colored, turbid; acid; specific gravity 1.010; no albumin, sugar, cells or casts found. *Wassermann and Kahn reactions:* negative. *Blood counts:* July 3, 1940—red blood cells 4,120,000; white blood cells 12,000, with 88 per cent polymorphonuclears, 11 per cent lymphocytes and 1 per cent monocytes. Hemoglobin 80 per cent. Blood count on July 10, 1940—red blood cells, 4,320,000; hemoglobin 85 per cent; white blood cells 7,300, with 71 per cent polymorphonuclears, 27 per cent lymphocytes and 2 per cent eosinophiles. No nucleated red blood cells. No polychromatophilia or poikilocytosis. *Sputum*: no tubercle bacilli found on specimens taken on July 3 and 5, 1940.

Patient refused to submit to a fractional analysis of the stomach contents.

Course. On admission here, evidence of weight loss was obvious. Patient was dyspneic and had a productive cough, and pain in the left chest was severe. A biopsy taken July 18, 1940, from the chest wall in the left axillary line, was reported, "Undifferentiated malignant tumor, probably carcinoma."

Roentgenographic study of the chest showed

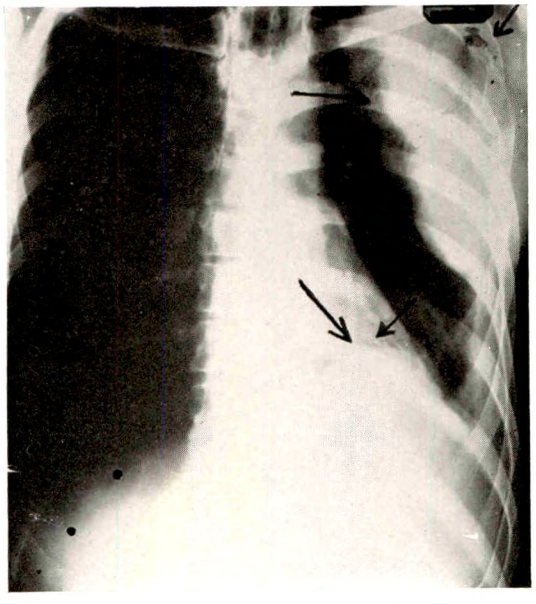


Fig. 1. Potter-Bucky roentgenogram of the chest, demonstrating the radiopaque masses in the left thorax, at its upper lateral aspect, and at its base overlying the cardiac shadow.

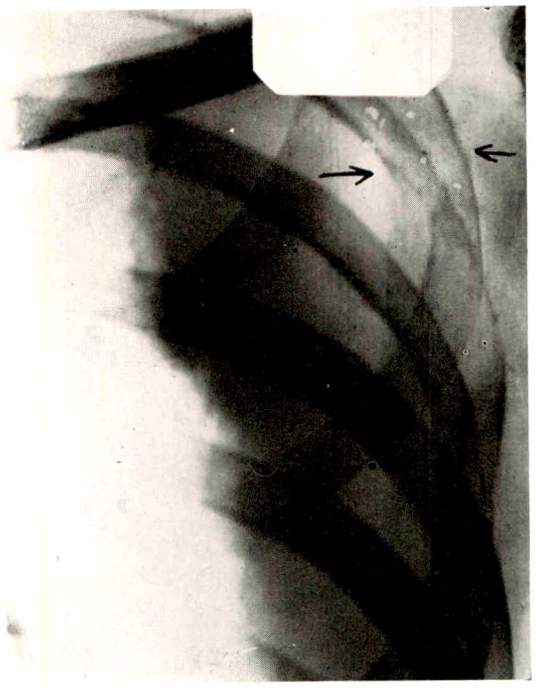


Fig. 2. A Potter-Bucky roentgenogram of the left upper chest, to show the rib erosion described in the text.

the masses similar to those described at Receiving Hospital (Fig. 1) with erosion of the second, third and fourth ribs (Fig. 2). Because the patient experienced some abdominal distress, vomiting and diarrhea during his third week of hospitalization, a gastrointestinal study was done, to seek a primary growth, on July 26 and again on August 2. An ulcerated filling defect of the pars media near the lesser curvature was visualized (Fig. 3) and a roentgen diagnosis of new-growth of the stomach was made, although the filling defect was not seen during the roentgenoscopic examinations. The thoracic masses were therefore interpreted as metastases from a malignant lesion (probably carcinoma) of the stomach.

However, the patient became progressively weaker; his abdomen became distended, and a hard irregular mass appeared in the right epigastrium and right hypochondrium, in addition to the mass bulging outward in the upper aspect of the left lateral chest wall, which was hard and tender. He died on September 20, 1940.

Necropsy. The pertinent findings were in the thorax, abdomen and lumbar spine. *Right thorax* showed only a few small tumor nodules in the right lower lobe, 5 to 7 mm. in diameter.

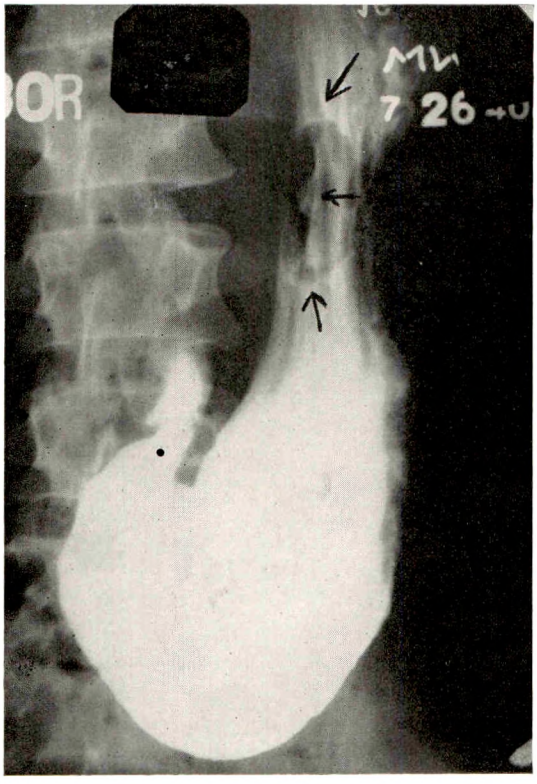


FIG. 3. Roentgenogram of the stomach with contrast meal, displaying in distinct relief the ulcer crater and surrounding filling defect in the mucosal pattern of the upper portion of the pars media.

Left thorax was occupied largely by a huge tumor mass extending through the pleura, involving the thoracic wall and eroding the second, third and fourth ribs laterally to form a firm mass in the left axilla. A similar mass was found at the base of the left hemithorax, infiltrating the diaphragm. The left pleura and the pericardium were exclusively thickened by tumor tissue and there was a shaggy fibrinous pericarditis. The parenchyma of the left lung contained scattered tumor nodules. *Abdomen:* the gastric mucosa contained a raised tumor mass, 5 cm. in diameter, on the posterior wall of the fundus, whitish-yellow in color, with firm raised margins and slight ulceration centrally. There were tumor masses also in the mesenteric glands and perirenal fat; the surfaces of the gallbladder and liver and the peritoneum were studded with nodules. *Spine*: a nodule, 6 mm. in diameter, was found in the body of the second lumbar vertebra.

Histopathologically, the gastric tumor was found to infiltrate deeply and extensively; the cells were oval or elongated, arranged in irregular bands and sheets, and appeared similar to smooth muscle in the more differentiated portions of the neoplasm. The growth was very cellular with such findings as intercellular bridging, mitoses and hyperchromatic nuclei being common (Fig. 4). All the metastases presented a similar picture. Microscopically, there was malignant invasion of the myocardium also.

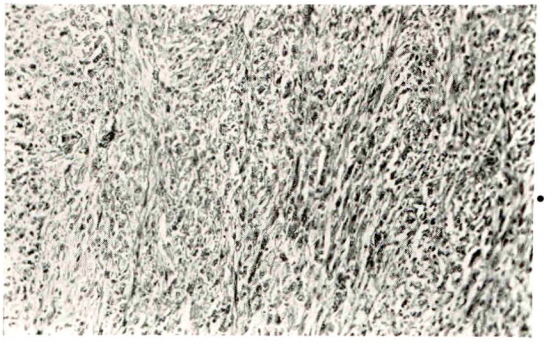


FIG. 4. Photomicrograph of section of the malignant lesion, showing irregular arrangement of the cells in muscle-like bundles and whorls, mitotic figures, intercellular bridging, atypism and hyperchromatic nuclei, and demonstrating the sheet-like, massive growth of the neoplasm.

The anatomical diagnoses, here, were:

(1) Leiomyosarcoma, Grade 3, of the stomach, with metastases to the left diaphragm, pleura, lungs, pericardium, heart, mesenteric glands, serosa of gallbladder, surface of the liver, peritoneum, left perirenal fat, ribs and second lumbar vertebra.
(2) Pericarditis, serofibrinous, acute.

SUMMARY

A case of leiomyosarcoma of stomach, with large and extensive metastases, is presented here. It is an illustration of the difficulty in diagnosis of this type of gastric tumor, and of the oft-repeated masking of the primary growth by the symptom-producing metastases. Here, the thoracic metastases were huge and, from a roentgenologic standpoint alone, might conceivably have been ascribed to mesothelioma of pleura or cancer of the lung, so that the necessity of a search for a primary

tumor, as was done in this example, is emphasized. In such an investigation, roentgenologic study is of primary importance. The roentgen characteristics—a relatively normal mucosal pattern, except in the immediate region of the filling defect or the ulceration and normal peristalsis roentgenoscopically—are also illustrated in this case. It is noteworthy that, until the patient's condition was terminal, there was no hint, clinically, of any intra-abdominal disorder or new-growth.

The authors are indebted to Ralph Creer for photographing the illustrations accompanying this article.

REFERENCES

1. Baumgartner, C. J. Leiomyosarcoma of stomach; perforation. *West. J. Surg.*, 1939, *47*, 27–30.
2. Chaffin, L. Smooth muscle tumors of stomach. *West. J. Surg.*, 1938, *46*, 513–524.
3. Ewing, J. Neoplastic Diseases. Fourth edition. W. B. Saunders Co., Philadelphia, 1940.
4. Jordan, Sara M. Case of multiple leiomyosarcomata of stomach. *Surg. Clin. North America*, 1938, *18*, 683–686.

MELORHEOSTOSIS

REPORT OF A BILATERAL CASE

By J. W. J. CARPENDER, M.D.,[1] D. R. BAKER, M.D.,[2] S. P. PERRY, M.D.,[3] *and* TOM OUTLAND, M.D.[4]
SAYRE, PENNSYLVANIA

THIS unusual condition was first described by Léri and Joanny in 1922 at which time they suggested the name of melorheostosis or flowing periostitis. Three years later a case listed as an unclassified osteosclerosis was published by Lewin and MacLeod. In 1932 Kraft reported a number of cases and reviewed all the other recorded cases, a total of 19 at that time. Widmann and Stecher, in 1935, reviewed the subject thoroughly and classified the condition into four groups: complete continuous flow, partial continuous flow, interrupted flow and circumscribed flow. They believed that the evidence supported the theory of Zimmer, namely, that the condition was caused by embryonic metameric disturbance. They stated that the lesion involves the derivatives of the anlage of a single extremity and that pathognomonically the remainder of the skeleton is unaffected. Franklin and Matheson in a recent paper list 38 cases reported since 1922 and present 1 of their own. Of these cases, 19 occurred in males and 12 in females while sex was not mentioned in the remaining eleven. In 19 of the cases the lesions were in the lower limb and in 18 in the upper. Five cases departed from the characteristic monomelic involvement but none showed bilateral involvement as in the case here presented. In personal communications, we have heard of one case at Johns Hopkins Hospital and another at Boston City Hospital which with our own case makes a total of 42 cases known to date.

PATHOLOGY

Widmann and Stecher stated that of the cases reported biopsy had been obtained in only 5 and so far no autopsies had been included. Cortical hyperostosis of dense sclerotic bone either endosteal, periosteal, or both, characterizes the benign progressive lesion which, roentgenologically, produces the effect of dripping or flowing candle wax. There is atrophy in the length of the involved bones and no expansile enlargement has been noted. As was previously stated, the lesions, as heretofore described, involve the derivatives of the anlage of a single extremity. The group classification of the lesions is self explanatory. Microscopic examination of specimens obtained has shown marked density of the osseous lamellae with overcrowding and bizarre formations. In all but one case mentioned by Léri there was a reduction in the number of osteoblasts.

SYMPTOMATOLOGY

The condition is probably not so rare as has been believed. The diagnosis is usually made by the roentgenologist but careful review of a history which is principally concerned with vague, low grade pain, usually confined to one extremity should bring this condition to the mind of the clinician.

The symptoms are sporadic and may disappear for months or years. Deviation of the involved digits with impairment of their articular motion is common, the former early and the latter late. Shortening of the involved parts with soft tissue atrophy is almost constant.

Laboratory studies have been found to be of no value in making a diagnosis except to rule out other conditions. No treatment has been of any avail. The condition must be differentiated from syphilis, tubercu-

[1] Formerly Fellow in Radiology, Robert Packer Hospital. Now Lieut. MC-V(S) USNR
[2] Fellow in Orthopaedic Surgery, Robert Packer Hospital.
[3] Formerly Radiologist, Robert Packer Hospital. Now Lieut. Comdr. MC-V(S)USNR
[4] Formerly Chief of Orthopaedic Surgery, Robert Packer Hospital.

losis, ossifying periostitis and calcinosis. The specific roentgenographic findings will generally suffice to do this, supplemented by negative laboratory finding.

CASE REPORT

The patient, a white female, was first examined on March 25, 1931, at the age of ten years; she was referred to the clinic from the Pennsylvania Crippled Children's Clinic because of a peculiar gait which had been present for a period of months, according to the history obtained at that time.

Examination revealed what appeared to be an abduction contracture of the left hip. As a result of this, the patient exhibited a marked apparent lengthening of the left lower extremity, due to the downward tilt of the pelvis. There did not appear to be any particular weakness in the adductors on the left side to account for the abduction contracture. A tentative diagnosis of mild residual poliomyelitis was made.

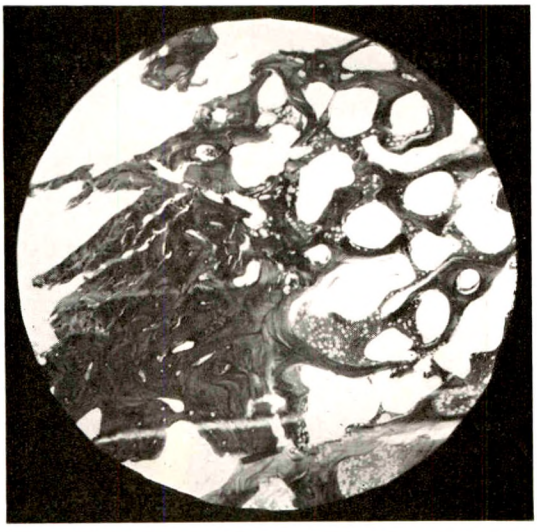


Fig. 1. Cortical bone from the lateral surface of the ilium.

Operation was performed June 13, 1931, for correction of the fixed pelvis obliquity. The operation consisted of incision of the fascia lata and osteotomy of the greater trochanter to relieve the gluteus medius.

Examination approximately six weeks later revealed complete correction of the pelvic obliquity. The patient walked with practically a normal gait. It was noted, however, that she had a moderate degree of genu valgum and marked pronation of the feet, bilaterally.

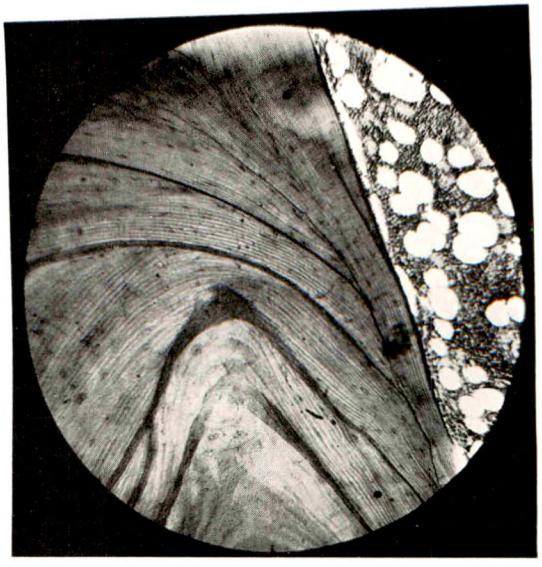


Fig. 2. Cortical bone from the upper third of the anterior portion of the femur.

The patient was again seen on June 29, 1939. At that time she complained of cramping and pain in the right hip and leg. She stated that this had been present for several years and was increasing in severity. The pain was described as shooting in character, originated in the lumbosacral area but radiated down the leg in the sciatic distribution and also down the front of the right thigh.

Examination showed a marked contracture of the right iliotibial band. Ober's and Ely's signs were marked positively on the right. Section of the right iliotibial band was carried out on June 30, 1939.



Fig. 3

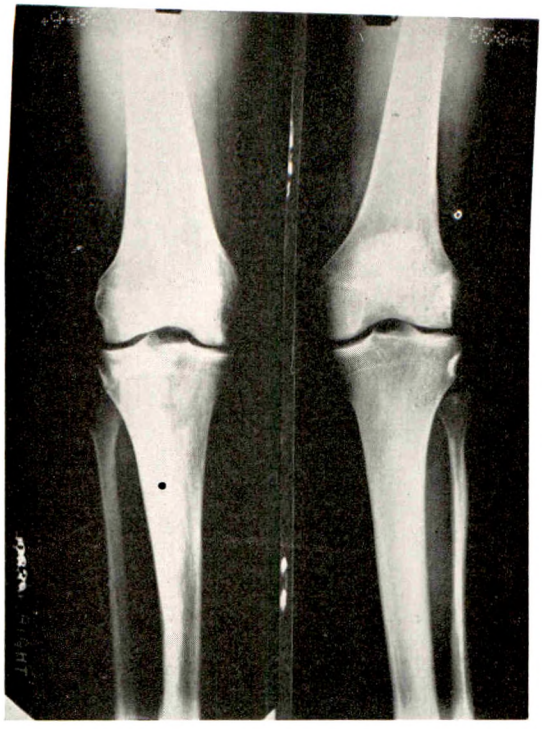


FIG. 4



FIG. 5

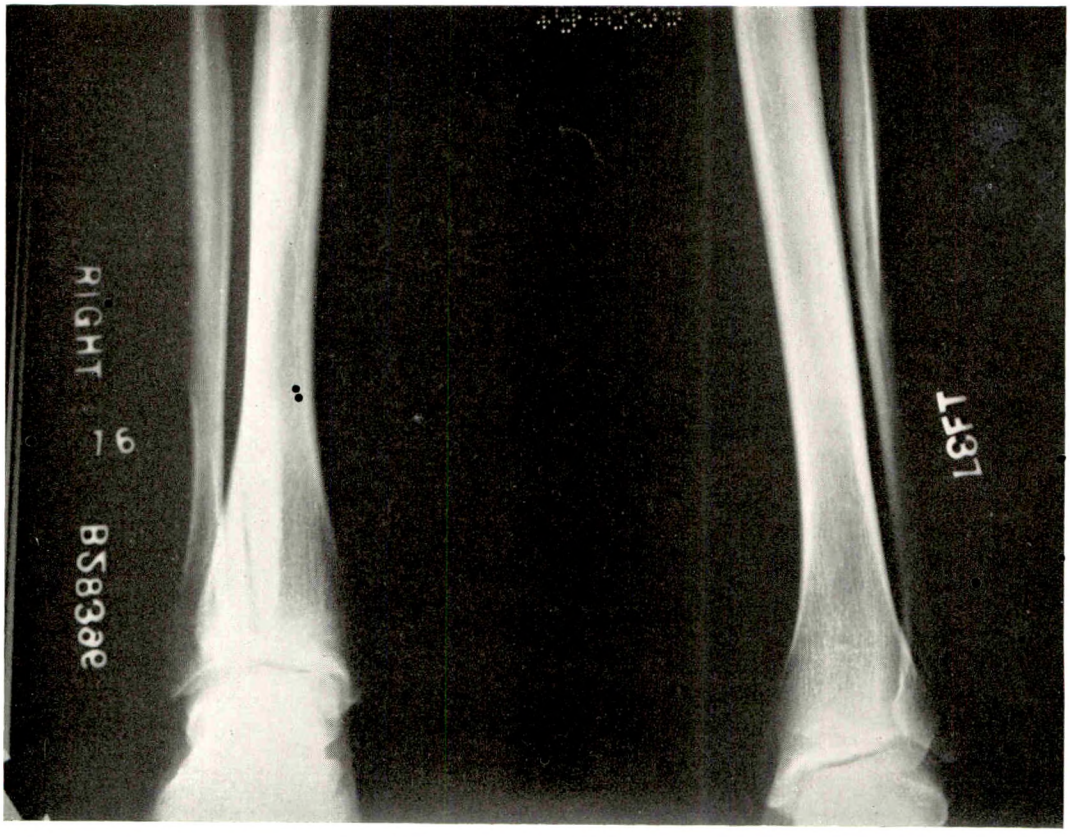


FIG. 6

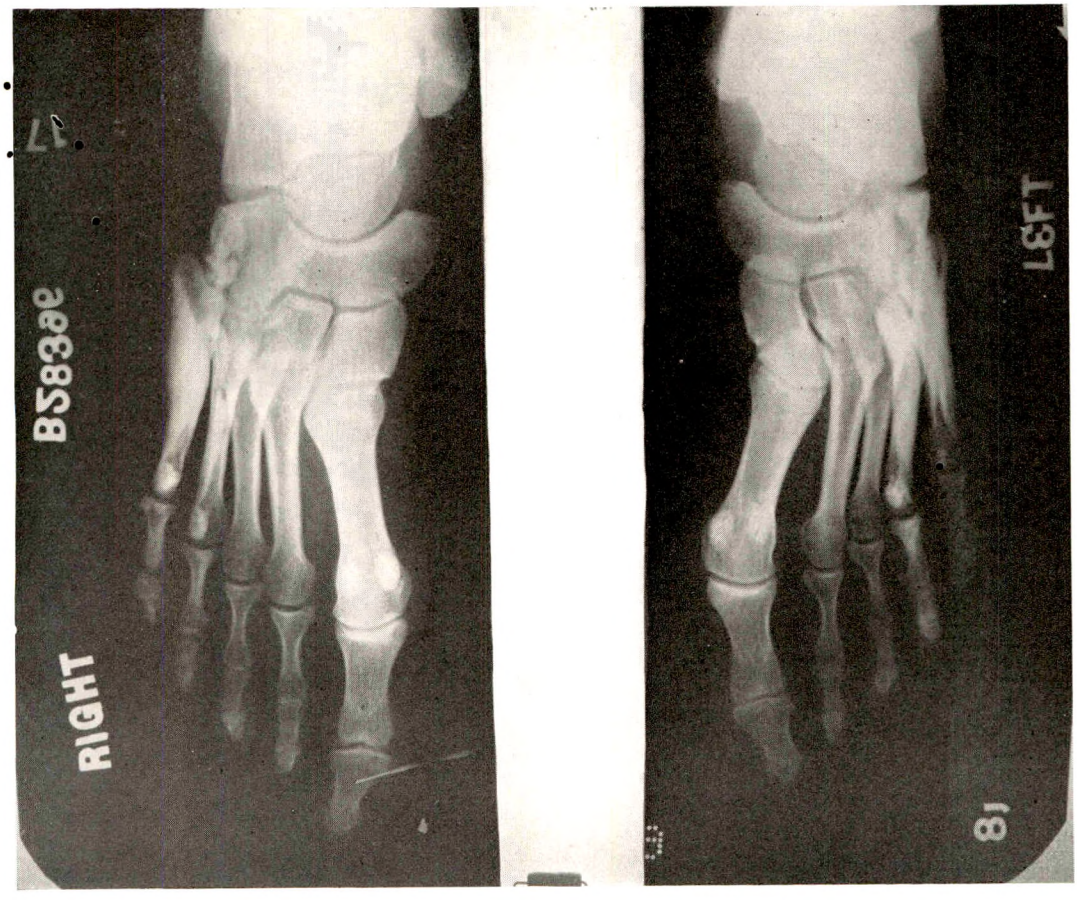


Fig. 7

Three months following the Ober operation, the patient returned to the clinic. She had been entirely pain free since the operation but noted considerable restriction of motion in the right hip joint.

Examination showed no flexion deformity when standing. Flexion, however, was limited to 90 degrees. Rotation was moderately restricted. Ober's sign was negative. There was 1 inch bone shortening involving the right lower extremity, and the right thigh was grossly hypertrophied, measurement showing 2 inch hypertrophy at mid-thigh and 1 inch just above the right knee.

Roentgenograms taken at this time led to the diagnosis of the pathologic entity. A review of these findings will follow later in the report, together with other laboratory data.

A complete review of this patient's past history was undertaken to bring out any significant points previously overlooked. Briefly, the patient was born at home, the sixth child and, according to the patient's belief, instruments were used. Walking was delayed well into the second year and the patient stated she dragged her left foot when walking. The family history was negative for any evidence of this disease in the preceding two generations. The past history was non-contributory except for measles in childhood and infectious jaundice at the age of twelve years. Menstrual onset was at the age of thirteen years, very irregular, one or two month intervals, lasting eight days. Recently, her periods have become more regular, occurring at three or four week intervals, lasting seven or eight days.

The patient stated that following the first operation until the age of fourteen years, she had no difficulty walking. The symptoms, starting at the age of fourteen, became progressively worse until the second operation, at which time pain was severe enough to interfere with sleep. At the second operation her general health was good; weight was 138 pounds.

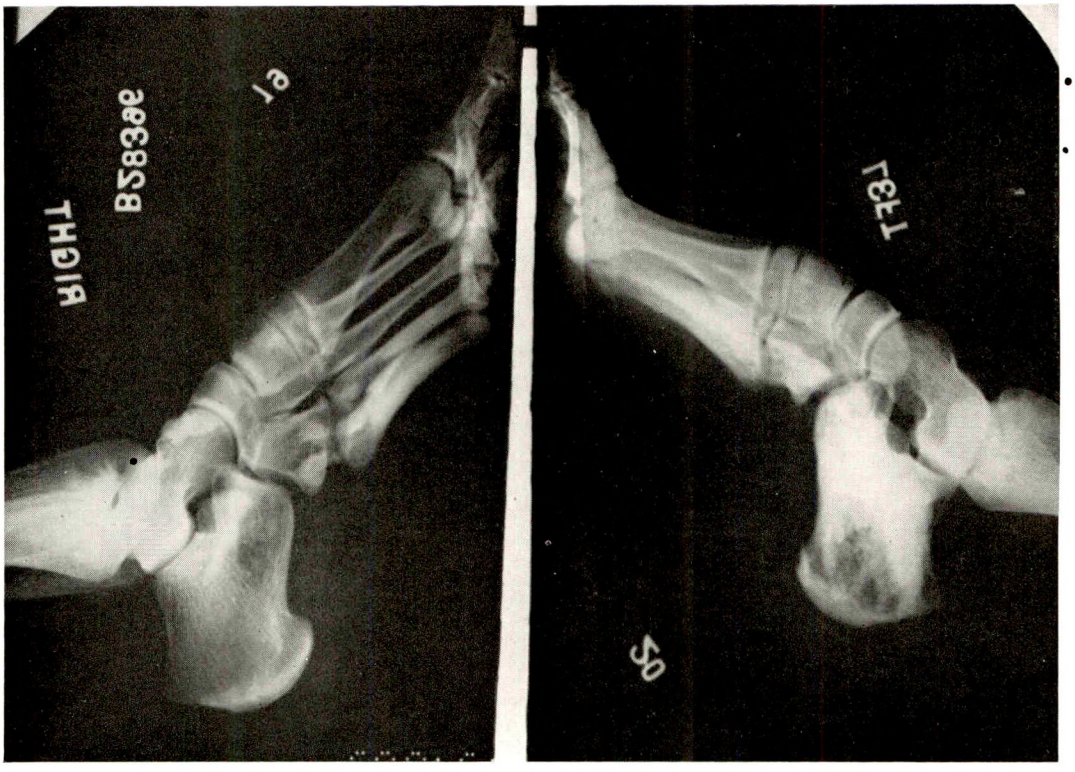


FIG. 8

This patient was seen again on January 15, 1940, when she reported excellent general health, some lower lumbar pain at times, no pain in the hips, some cramps in both legs and no trouble with her feet since wearing corrective supports. There was no clinical evidence of changes. Hypertrophy of the right lower extremity was still present.

On September 17, 1940, the patient returned again complaining of "prominence of the right hip." Upon examination, flexion was limited to about 70 degrees. It was believed, at that time, that restriction of motion was due to excessive ostosis about the femoral head. Roentgenograms showed the extent of the melorheostosis relatively unchanged.

The patient was admitted to the hospital on October 2, 1940, when significant changes were found. An operation was performed of which the transcript follows: "The usual approach to the right hip by the Smith-Petersen acetabulum incision was made. When the incision was extended deeply it was found that there was a continuous sheet of adhesions of tough, thickened fascia surrounding the structures of the hip joint. This was dissected free. In places this fascia was 2 to 3 mm. thick and far more tough than the normal hip joint capsule. A sheet of it, approximately 4 inches long and 3 inches wide, was removed. The anterior third of the hip joint capsule was removed, which demonstrated free motion at the hip joint with no exostoses. With the wound open, passive motion of the hip was attempted in flexion and abduction. It was found that passive flexion could be easily secured and for about 30 degrees beyond right angles and abduction of about 40 degrees secured. There was therefore no indication for removal of bone for the purpose of increasing motion. The femoral head appeared to be covered by an abnormally large layer of cartilage, the whole appearing like the femoral head of a child seven to nine years of age although adult in size. Bone biopsies were taken as follows: (1) small wedge from the anterior portion of the acetabular lip; (2) cortical bone from the side of the ilium (Fig. 1); (3) cancellous bone from the side of the ilium; (4) cortical bone from the upper third of the anterior portion of the femur (Fig. 2).

"The wound was then closed in layers with reattachment of rectus femoris by several

mattress sutures of chromic catgut. The muscles originating from the iliac crest were reattached to their origin. Deep fascia was not closed, and an additional layer of plain catgut was placed close to the superficial fascia. The skin was then closed with a running stitch of black silk."

After a moderately stormy postoperative course the patient was discharged on November 23, 1940. When seen on January 7, 1941, she stated that she was pleased with the results of the operation. She was walking well at that time.

Roentgen and Laboratory Studies. During the course of a clinic visit on September 8, 1939, a roentgenogram of the pelvis disclosed the involvement of the area and, as a consequence, the entire skeleton was examined. The roentgen report follows: "There are multiple lesions in the skeleton, all having similar characteristics. The lesions are long striations which, according to textbook descriptions, resemble the dripping tallow from a candle. It was difficult to be absolutely certain but the lesions are definitely cortical and are probably subperiosteal in nature and probably represent the disease entity known as melorheostosis or flowing periostitis. These lesions involve both ilia, right femur, right tibia and, to a lesser extent, the lateral condyle of the left femur, the left fourth and fifth metatarsals, the left cuboid and left calcaneus; in the right foot, the fourth and fifth metatarsals and lateral half of the cuboid. In the right foot all of the phalanges of the fifth toe are similarly involved whereas in the left foot all the phalanges of the fourth toe are involved. Roentgenograms of the skull fail to demonstrate any evidence of this disease. Roentgenograms of the thoracic and lumbar spine demonstrate a mild degree of scoliosis to the left with the point of maximum convexity at the level of the eleventh thoracic. There are some striations in the vertebral bodies, extending from the level of the seventh thoracic down and including the first lumbar. There is a moderate degree also of lordosis in the upper lumbar spine. Roentgenograms of the upper extremity include both humeri, both forearms and both hands and fail to demonstrate any evidence of this disease in the upper extremity. Impression: (1) melorheostosis (flowing periostitis) involving the pelvis, both lower extremities (more extensive on the right than on the left) and the thoracolumbar spine; (2) scoliosis to the left in the lower thoracic region and a moderate degree of lumbar lordosis."

Figures 3 to 8 demonstrate the involved areas with the exception of the lumbar spine which was not deemed suitable for reproduction as an illustration. Figure 9 is a schematic drawing of the areas involved. Later roentgen examinations, most recently on September 17, 1940, showed no demonstrable progression of the disease.

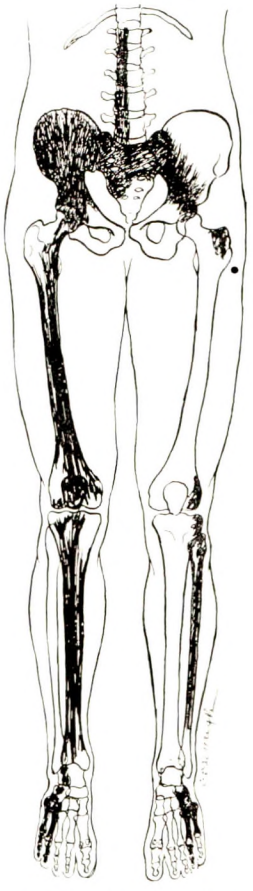


Fig. 9. Schematic drawing showing areas involved.

At the same time, detailed laboratory studies were done. The blood count showed red blood cells 3,960,000; 77 per cent (12 gm.) hemoglobin; white blood cells 6,000; with a differential of 82 per cent polymorphonuclears and 18 per cent lymphocytes. The Kahn reaction was negative and the blood sugar was 105 mg. per 100 cc. A sample of blood was sent to Dr. A. B. Gutman of Presbyterian Hospital in New York City, who had kindly consented to do detailed blood chemistry for us. His report was as follows: Serum inorganic phosphorus 3.2 mg. per

100 cc.; serum phosphatase 3.5 Bodansky units per 100 cc.; serum calcium 10.3 mg. per 100 cc.; non-protein nitrogen 30 mg. per 100 cc.; bilirubin no color; serum protein 8.3 per cent; serum albumin 5.1 per cent; serum globulin 312 per cent; serum euglobulin 0.4 per cent.

The pathological specimens obtained at operation on October 3, 1940, were sent to Dr. C. Howard Hatcher of Chicago, Illinois, who reported that with the exception of the cancellous bone from the ilium all the specimens showed considerable sclerosis of cortical bone with some increase in the osteoid tissue along the trabeculae. No unusual pathologic change was seen to distinguish this from any other bizarre sclerosis of bone.

SUMMARY

The literature on thirty-nine reported cases of melorheostosis is briefly reviewed and two hitherto unreported cases are listed.

A report of the only known case of melorheostosis with bilateral involvement is given. Aside from the fact that this case shows bilateral involvement it does not differ from others reported previously.

REFERENCES

1. FRANKLIN, E. L., and MATHESON, I. Melorheostosis; report on a case with review of the literature. *Brit. J. Radiol.*, 1942, *15*, 185–191.
2. KIBBY, S. V. Melorheostosis, with report of a case. *Radiology*, 1941, *37*, 62–67.
3. KRAFT, E. Melorheostosis Léri; a flowing hyperostosis of a single extremity; report of two cases. *J. Am. M. Ass.*, 1932, *98*, 705–709.
4. LEWIN, P., and MACLEOD, S. B. Osteosclerosis with distribution suggesting that of the ulnar nerve; an unclassified bone condition. *J. Bone & Joint Surg.*, 1925, *7*, 969–981.
5. WIDMANN, B. P., and STECHER, W. R. Rhizomonomelorheostosis. *Radiology*, 1935, *24*, 651–670.

Vol. 49, No. 3

HEMOPHILIC ARTHRITIS

ROENTGENOGRAPHIC STUDIES IN FIFTEEN ADULT PATIENTS WITH HEMOPHILIA*

By EUGENE J. McDONALD, M.D., *and* EUGENE L. LOZNER, M.D.
BOSTON, MASSACHUSETTS

HEMOPHILIA may seem of only slight importance to the roentgenologist because of the infrequency of this disorder. It is, however, of considerable significance because of the occurrence of joint involvement which may simulate other conditions for which operative intervention may be indicated. That this intervention must be prevented by means of a correct differential diagnosis is obvious from the definition of hemophilia, namely, a disorder characterized by prolonged and immoderate hemorrhage dependent upon delayed coagulation of the blood, seen only in the male but transmitted through the female.[7]

The clinical aspects of hemophilic arthritis have been reviewed by Key,[5] Keefer and Myers,[3] and Freund.[1] Two stages are generally recognized: (1) that of the acute hemarthrosis, either spontaneous or traumatic in origin, in which the joint is acutely distended with blood, and (2) that of the chronic degenerative arthritis which may involve the joint following one or more hemarthroses.

It is the purpose of this communication to report roentgenographic studies on 15 adult patients with hemophilia, ranging in age from thirteen to fifty-two years. The venous blood coagulation time was considerably elevated in every patient, and the diagnosis of hemophilia unmistakably proved.

In all 15 cases, anteroposterior and lateral roentgenograms of both knees and both elbows were taken. In most of the cases, roentgenograms were taken of both ankles. In patients who presented clinical evidence of other joint involvement or a history of hemarthroses involving other joints, roentgenograms were also taken of these. Most of the patients were ambulatory, and no particular effort was made to secure roentgenograms of acute hemarthroses except as they happened to occur during the period of study.

The degrees of roentgenographic joint changes observed are presented in Table 1. For purposes of classification, four degrees of pathologic involvement were defined as follows:

0 = no demonstrable roentgenographic change.
1+ = mild involvement shown by spurring at margins of joint with slightly increased periarticular density.
2+ = moderate involvement shown by early narrowing and irregularity of joint space with evidence of early subchondral cysts and capsular fibrosis.
3+ = severe involvement shown by marked narrowing and irregularity of joint space with marked subchondral cystic changes.

In all 15 cases roentgenographic changes were demonstrable in the knee on one or both sides. Similarly, the elbow was affected in all but one patient. In general, it would appear that the degree of involvement increased proportionally with the age of the patients. The 2 youngest patients observed, thirteen and eighteen years old, had the least involvement. There were 16 joints roentgenographed of these two boys and only 3 presented demonstrable pathologic changes. On the other hand, the 3 oldest patients, thirty-four, thirty-six, and fifty-two years old, presented the greatest involvement; in these men, of 22 joints roentgenographed 20 showed pathologic changes.

* From the Department of Roentgenology, Boston City Hospital and from the Thorndike Memorial Laboratory, Second and Fourth Medical Services (Harvard), Boston City Hospital, and the Department of Medicine, Harvard Medical School. Presented in part at the meeting of the New England Roentgen Ray Society, February, 1941, Boston, Mass.

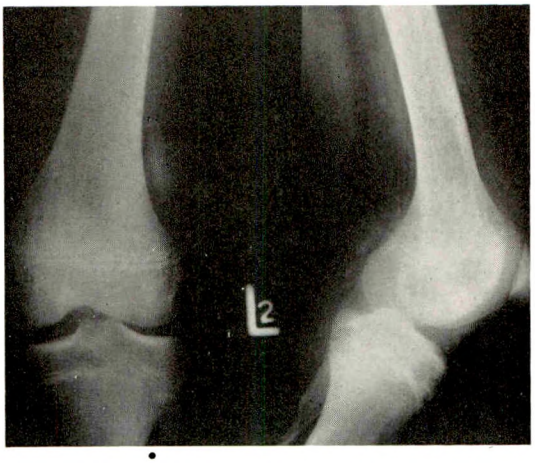


FIG. 1. Case I. Age thirteen years. Left knee shows no joint or bone involvement but presents marked periarticular density which corresponds approximately with synovial capsule. The density appears fibrous in character.

The actual roentgenographic appearances of typical joints are illustrated in Figures 1 to 5.

DISCUSSION

An experimental study of the action of blood on the synovial membrane and a study of the anatomical changes in hemophilic joints have been reported on by Key.[4,5] He observed that two factors were concerned in the reaction of the membrane: one, mechanical and the other chemical. Following the instillation of blood into a joint cavity, marked cellular reaction takes place in the synovial membrane. The macrophages phagocytose the red cells and settle in the subsynovial tissues beneath the capsule. Eventually there is a tendency to fibrous ankylosis due to thickening and shortening of the joint capsule. The broken down iron pigment deposits may cast a dense roentgen shadow and may even be mistaken for calcification. The cartilage in most instances of chronic hemophilic arthritis appears irregularly serrated due to spotty absorption and adjacent proliferation. There is narrowing of the interarticular surfaces but not necessarily at the point of maximum weight bearing. The periphery of the articular cartilage, even in early cases, frequently shows spurring due to proliferating osteophytes.

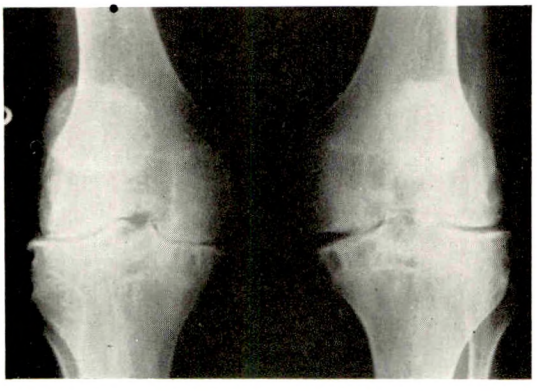


FIG. 2. Case XII. Age twenty-seven years. Both knees present moderate involvement with narrowing and irregularity of joint space. Spurring is seen at periphery of the articular surfaces. Subchondral cysts are present. Capsular changes are not remarkable.



FIG. 3. Case VI. Age twenty-three years. The left elbow presents clouding in the antecubital fossa of fibrous tissue density. There are cystic changes in the capitulum of the humerus and the head of the radius.

Characteristically, the changes in the bone tissue are those of subarticular cystic absorption. Diffuse decalcification of the bone from disuse may accentuate these cystic areas. The diameter of the cysts varies from less than a millimeter to more than a centimeter, and the cysts may be round or irregular and single or loculated. The mechanism of origin of these cysts is controversial. Freund[1] believes that it is necessary, in part, to assume that hemo-

philic blood exerts some as yet unkown chemical effect on bone tissue. Key,[5] on the other hand, inclines to the opinion that an intraosseous hemorrhage occurs in bone already decalcified from limited use and that the hemorrhage being of hemophilic origin progresses to cause an area of aseptic pressure necrosis in the bone.

It is of interest to note here that not all hemarthroses are followed by these changes. Many of our patients gave a history of occasional hemarthroses in joints which are now roentgenographically negative. Gocht[2] has reported a patient with 45 hemarthroses into a single joint without permanent cartilaginous or bony changes.

The joint conditions which must be differentiated from hemophilic arthritis may be divided into two groups according to which stage of the hemophilic condition they resemble, namely (1) acute hemarthrosis and (2) chronic degenerative arthritis.

Acute hemophilic hemarthrosis simulates roentgenographically any traumatic, serous or purulent synovitis in which the joint space is distended with fluid. The joint by preference is held in partial flexion, for it is in this position that the capsule has its greatest capacity, producing therefore the least tension. There is generalized periarticular clouding of soft tissue appearance,

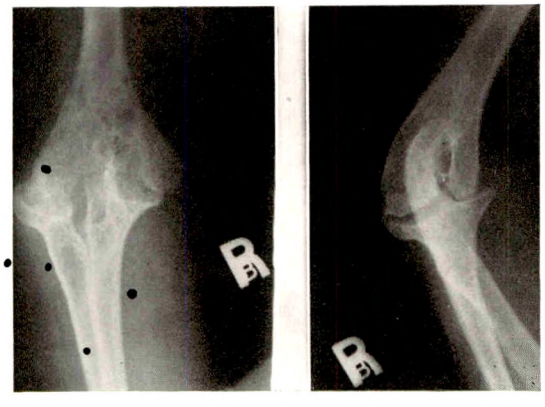


Fig. 4. Case xiii. Age thirty-four years. Right elbow presents deformity due to repeated hemarthroses before epiphyseal fusion. There is flaring at both articular surfaces, general periarticular density, and marked cystic decalcification.

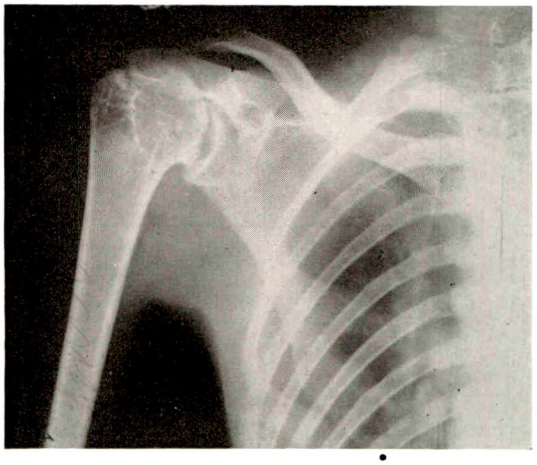


Fig. 5. Case ix. Age twenty-five years. Left shoulder presents a single sharply defined area of articular necrosis on the outer superior surface of the humeral head just within the capsular attachment. The picture resembles tuberculous caries sicca but in the latter condition the articular surface is usually shaggy and scalloped.

most marked along the lines of the distended capsule. Roentgenological differential diagnosis is almost impossible at this stage nor is one usually able to differentiate the hemophilic hemarthrosis from the hemarthroses which may occur traumatically in the normal individual or spontaneously in certain other hemorrhagic diatheses.

In the chronic stage, roentgenographic differential diagnosis is more frequently possible. Differentiation must be made first from osteoarthritis which usually occurs after forty-five years of age. In hemophilia, roentgenographic changes about a joint are very apt to be seen before the age of twenty-one. Cystic changes in the bones may be seen in both conditions. They are the rule in hemophilia and much less common in osteoarthritis. Generalized decalcification is more often seen and usually more severe in hemophilic than in osteoarthritis.

Differentiation from rheumatoid arthritis is suggested first of all by the location, since in the rheumatoid condition wrists and phalanges are far more frequently involved than in the hemophilic. In rheumatoid arthritis bony ankylosis of the joint is not uncommon but this is a distinct

TABLE I

SUMMARY OF THE DEGREES* OF PATHOLOGIC INVOLVEMENT OBSERVED ROENTGENOGRAPHICALLY IN THE JOINTS OF FIFTEEN PATIENTS WITH HEMOPHILIA

Case No.	Age Yr.	Hip		Knee		Ankle		Shoulder		Elbow		Wrist		Hand	
		R	L	R	L	R	L	R	L	R	L	R	L	R	L
I	13			○	2+	○	○			○	○	○	○		
II	18			○	2					○	2+	○	○	○	○
III	22			1+	1+	1+	1+			1+	1+				
IV	22			2+	3+			○	○	2+	○	○	1+	○	1+
V	23			2+	2+	○	○			2+	○				
VI	23			2+	○	1+	○			○	3+				
VII	23			2+	2+					○	1				
VIII	23	○	○	2+	3+	1+	1+			1+	1+	○	1+		
IX	25			2+	2+			○	3+	3+	3+				
X	25			1+	3+	1+	2+	○	○	1+	1+				
XI	25			2+	3+	○	○			1+	2+	○	2+		
XII	27			2+	2+					○	3+				
XIII	34	3+	○	3+	3+			3+	○	3+	3+				
XIV	36			3+	3+	3+	3+			2+	2+	2+	2+		
XV	52			1+	1+	1+	2+			2+	2+				

*○ = Negative. 1+ = Mild involvement. 2+ = Moderate involvement. 3+ = Severe involvement.

rarity in hemophilia. Subchondral cystic changes are much more frequently seen in hemophilic than in rheumatoid arthritis.

Tuberculous arthritis offers a serious challenge in differential diagnosis. It presents, however, an articular surface in which fine etching is absent and ragged and irregular scalloping is conspicuous.

When the roentgenographic changes of hemophilic arthritis are observed, the possibility of hemophilia should be suggested to the clinician in order that this diagnosis be eliminated before surgery is undertaken. The diagnosis of hemophilia cannot be made without the demonstration of a prolonged venous blood coagulation time. It has been pointed out, however, that in a young male with past and family history of hemorrhagic tendency and who shows joint involvement, a highly presumptive diagnosis can frequently be made.[7] The occurrence of the roentgenographic changes described here should contribute to that presumptive diagnosis.

SUMMARY AND CONCLUSIONS

1. Roentgenographic studies were made on the joints of 15 adults with hemophilia.

2. In every patient, pathological changes were observed roentgenographically in one or both knees; and in all but one patient, in one or both elbows.

3. In general, the degree of change increased proportionally with the age of the patient.

The authors appreciate the advice of Dr. P. F. Butler, Director of the Department of Roentgenology, Boston City Hospital.

REFERENCES

1. Freund, E. Die Gelenkerkrankungen der Bluter. *Arch. f. path. Anat.*, 1925, *256*, 158–189.
2. Gocht, H. Ueber Blutergelenke und ihre Behandlung. *Arch. f. klin. Chir.*, 1899, *59*, 482–503.
3. Keefer, C. S., and Myers, W. K. Hemophilic arthritis. *New England J. Med.*, 1933, *208*, 1183–1189.
4. Key, J. A. Experimental arthritis; reactions of joints to mild irritants. *J. Bone & Joint Surg.*, 1929, *11*, 705–738.
5. Key, J. A. Hemophilic arthritis (bleeder's joints). *Ann. Surg.*, 1932, *95*, 198–225.
6. Rypins, E. L. The roentgen ray as an aid in the diagnosis of hemophilia. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 597–602.
7. Stetson, R. P., and Lozner, E. L. Hemophilia. Oxford Medicine, 1941, Chap. xx, 799–818.

VOL. 49, NO. 3

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR
Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, cancelled.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary,* E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, cancelled.

EDITORIALS

ROENTGENOGRAPHY AS A DIAGNOSTIC AID IN PULMONARY FAT EMBOLISM

THE occurrence of fat embolism is common, and much more common than has been suspected according to reports which have appeared in the literature. Whitaker[1] writes that fat embolism is a definite, well established disease entity which is neither new nor infrequent. While this statement may be true, too often the diagnosis is made at the autopsy table, death having occurred without a true recognition of the causative factor until autopsy reveals the presence of multiple fat emboli throughout the lung fields and other portions of the body.

In many cases the emboli may not be severe enough to produce death or even clinical symptoms, but that they do occur with frequency is often overlooked or neglected as an explanation for some of the untoward symptoms which the patient manifests following fracture. With regard to the origin of the fat, speculation has arisen as to whether the injured bone is the sole source of the fat or whether there is some additional alteration in the normal lipoid content of the blood, since it has been claimed that there is not enough fat in any long bone of the body to cause death even if all of it should enter the circulation. However, it is generally believed that the chief source of the fat is the injured bone and that a small amount may reach the circulation by way of the lymphatics. The fat passes to the right side of the heart and from there enters the pulmonary circulation where it becomes lodged in the finer arterioles and capillaries. If the amount of fat is too great, it may act much the same as an air embolus on the heart and cause death before it reaches the lung.

The pathologic process which produces the clinical picture of fat embolism is brought about by the collection and lodgment of transient emboli in the capillaries, the symptoms produced being dependent on the number, the location and the duration of the emboli. The smaller arterioles being obstructed by the fat globule become surrounded by extravasated blood, bringing about a focal anemia, edema or necrosis.

Whitaker points out that while fat globules reach practically all parts of the body, symptoms are usually referable to the lungs and the brain. As a consequence there are two clinical types of fat embolism, namely, the pulmonary and the cerebral, depending on the preponderance of one group of symptoms over the other.

The symptoms of traumatic fat embolism may develop within a few hours or days. With the occurrence of the pulmonary type of embolism, respiratory and cardiac embarrassment are presenting symptoms, there being dyspnea, cough, cyanosis, restlessness and a feeling of constriction in the chest, and air hunger may develop. The pulse is usually rapid and may be irregular and the sputum becomes frothy and may be blood streaked. Râles are heard scattered over the pulmonary fields as the result of mild or severe pulmonary edema. There may be some dilatation of the right side of the heart and the blood pressure may be low.

In the typical cases of pulmonary fat embolism there should and may be no difficulty in diagnosis but in the less severe cases the actual condition may go unrecog-

[1] Whitaker, J. C. Traumatic fat embolism. *Arch. Surg.*, 1939, *39*, 182–189.

nized. Therefore, every patient presenting chest symptoms following an accident should be carefully studied in the light of the possibility of fat emboli having occurred.

Up to the time of the report of Scott, Kemp and Robb-Smith,[2] the value of roentgenology in the diagnosis of pulmonary fat emboli was not emphasized or an insufficient number of cases had been examined roentgenographically to give data upon which a differential diagnosis might be made. There observers have pointed out that the quality of the roentgenograms taken by the portable roentgen unit are not adequate for roentgen diagnostic aid in the less severe cases of pulmonary fat emboli. The roentgenographic findings are practically always typical of acute pulmonary edema and it has been emphasized that good roentgenograms are essential at the earliest possible moment and that the finest film detail should be obtained in order to make a diagnosis in the cases where there is minimal involvement of the lungs by fat emboli. With proper roentgenographic technique it may be possible to form a clinical conception of the degree of fat embolism not severe enough to produce acute pulmonary edema.

Scott, Kemp and Robb-Smith, from a study of one of their cases, came to the conclusion that considerable quantities of fat may be held up in the lungs, sufficient to cause definite functional impairment without causing roentgenographic changes. It is suggested that this lack of roentgen demonstration of changes might be due to an improper technique, particularly since so many of these patients are quite ill and cannot be moved, thus making it necessary that the examination be made with the portable bedside unit. However, with the capacity of the portable bedside units in vogue today it should be possible with proper care to demonstrate even minimal changes which occur particularly in the bases of the lungs where the fat emboli usually lodge.

Jirka and Scuderi,[3] in an effort to determine the possibility of making a diagnosis of pulmonary fat embolism by roentgenography, experimentally investigated the matter by examining the chests of dogs after oil had been injected into the blood stream. From their experimental work they concluded that roentgenograms should be of definite diagnostic aid in patients suffering from clinical fat embolism. However, some criticism has been made of their experiments by Scott, Kemp and Robb-Smith, because of faulty technique in the positioning of the animals at the time of exposure, and so forth.

Scott, Kemp and Robb-Smith had access to the records of experiments on adult cats and rabbits which Barclay, Franklin and Prichard conducted at the Nuffield Institute. By cineroentgenographic studies of the heart and lungs Barclay and his coworkers followed the course of globules of iodized oil in the pulmonary circulation and from a study of those films it was evident that the oil collects in the most dependent parts of the lung, and that considerable quantities may accumulate before there is any diminution in pulmonary translucency. However, it was judged that in these experiments the opaque oils did not induce fat embolism comparable to that which may be observed in fracture cases. Moreover, the iodized oil tended to be held up in the larger branches of the pulmonary artery, whereas the fat globules derived from tissue trauma are much smaller and pass into the arterioles and capillaries. These experiments seemed to confirm the impression that considerable quantities of fat must be present before there are any appreciable roentgenographic changes, and this tends to confirm the clinical impression.

That roentgenography of the chest may be of some aid in the diagnosis of pul-

[2] Scott, J. C., Kemp, F.H., and Robb-Smith, A. H. T. Pulmonary fat-embolism; clinical and radiological observations. *Lancet*, 1942, *1*, 228–230.

[3] Jirka, F. J., and Scuderi, C. S. Fat embolism; experimental study on the value of roentgenograms of the chest in diagnosis. *Arch. Surg.*, 1936, *33*, 708–713.

monary fat embolism is no longer a question. The assistance which it may give is dependent upon several things. For example, the clinician must recognize the possibility of fat emboli and the roentgenogram must be of sufficient quality to show the patchy mottlings and the early signs of acute pulmonary edema.

Perhaps if careful roentgenographic studies were made on a sufficient number of cases of pulmonary fat embolism, more satisfactory roentgen criteria might be established. The problem of the demonstration of pulmonary fat embolism offers a fertile source for experimental roentgen investigation.



Photo by Sarg-Taylor, New York

HARRY MYRREL STEWART
1876-1942

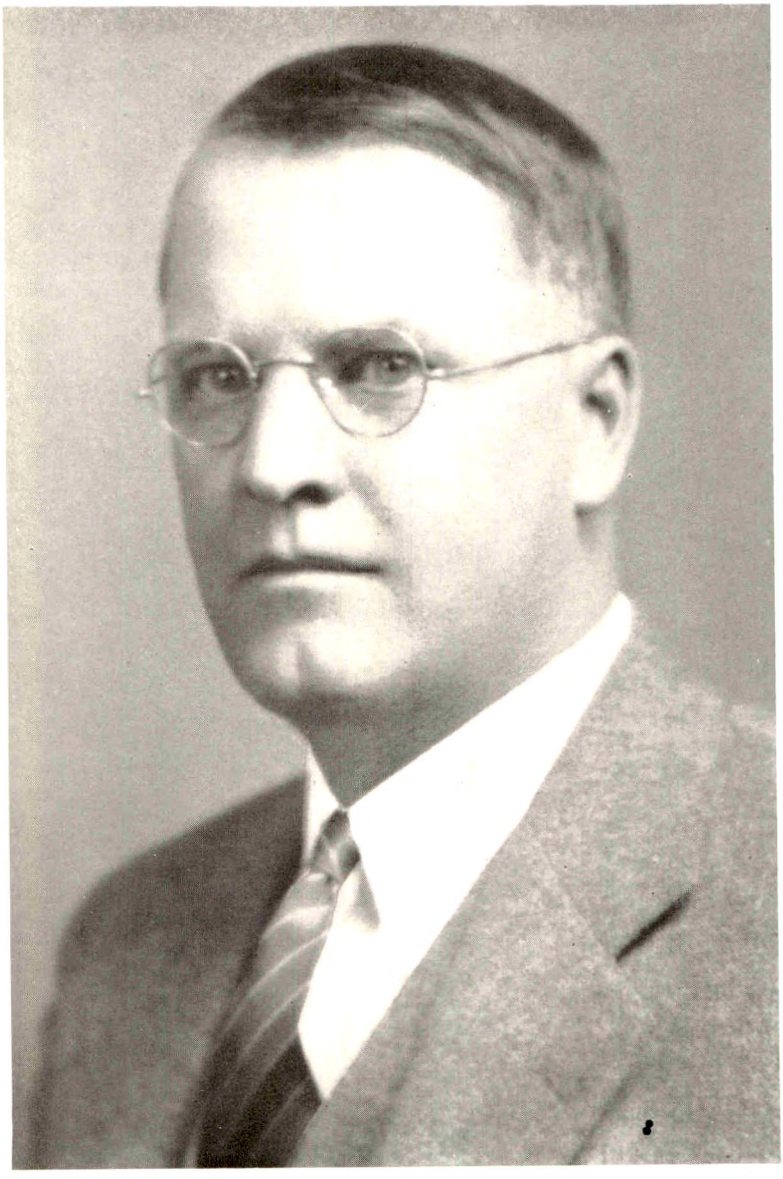
DR. HARRY MYRREL STEWART, a member of the American Roentgen Ray Society since 1917, died of a heart attack at his home in Johnston, Pennsylvania, on August 28, 1942, after an illness of three weeks. He was chief of radiology in the Memorial, Mercy and Lee Hospitals.

Dr. Stewart was born August 5, 1876, in Frankstown, Pennsylvania. After attending the Millersville, Pennsylvania, Normal

School, and Valparaiso University, he entered Jefferson Medical College, graduating in 1905. After practicing in Altoona and in Ehrenfeld, he decided to specialize in radiology and located in Johnstown. In 1914 he married Miss Edna Bauers, who survives him, together with a daughter, Louise, who was her father's technician. He leaves also three sisters and a brother.

In the first World War, Dr. Stewart served as a Captain in the Medical Corps of the Army. He was active in the Pennsylvania State Medical Society and was president of the Cambria County Medical Society in 1920. In 1918 he was president of the Pennsylvania Radiological Society. He was a diplomate of the American Board of Radiology, a member of the Radiological Society of North America, and a fellow of the American College of Physicians.

Ramsay Spillman



JOHN WATSON CATHCART
1877-1942

DR. JOHN WATSON CATHCART of El Paso, Texas, died September 13, 1942, of aplastic anemia.

Dr. Cathcart was born November 28, 1877, in Cerro Gordo County, Iowa, the son of William and Annie Cathcart. He attended the Mason City high school. He served in the Spanish-American War, after which he attended Northwestern University Medical School, graduating in 1903. He married Miss Ethel Hicks in 1901, in Mason City. He served an internship in the Hotel Dieu in El Paso, and spent all of his professional life in that city.

Dr. Cathcart was a past president of the El Paso County Medical Society. He was a

member of the American Roentgen Ray Society and of the American Radium Society, a fellow of the American College of Radiology, a member of the Texas Radiological Society, and of the Radiological Society of North America, of which he was a counsellor. He is survived by Mrs. Cathcart and by their daughter, Mrs. John F. Melby of Washington, D. C.; also a brother, David W. Cathcart, of La Mesa, California.

As early as 1903 Dr. Cathcart worked with the static machine, and incurred pathological changes on his hands, though they were not extensive. During the last few years of his life he handled practically no radium and did no roentgenoscopy. Tests showed that the therapy protection was adequate. Dr. C. H. Mason, his partner since 1920, states that Dr. Cathcart had been in poor health for a long time and being unable to take any exercise or spend much time outdoors, seemed to have a lowered resistance. The first warning of his fatal anemia was in December, 1941, following a severe epistaxis. From the last of January till his death, a period of some eight months, he had twenty-one transfusions. His death is mourned by a host of friends, patients, and colleagues.

Ramsay Spillman

VOL. 49 NO. 3

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1943, to be announced.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. Herman Klapproth, Sherman, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gustavin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

AMERICAN RADIUM SOCIETY

The Officers and the Executive Committee of the American Radium Society make the following announcement:

There will not be a 1943 meeting of the American Radium Society. The dues of the members in the Armed Forces are cancelled for the period of their military service. Members in the Armed Forces who wish to have their subscription to the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY continued must send in the subscription price of $10.00 per year to the Treasurer, Dr. Leland R. Cowan, Medical Arts Building, Salt Lake City, Utah. During the absence of Dr. A. N. Arneson in the military service, Dr. E. H. Skinner, 1532 Professional Building, Kansas City, Missouri, has been made Acting Secretary.

CANCER TEACHING DAY

A program under the title of Cancer Teaching Day and arranged under the auspices of a number of medical societies of Rochester and of the State of New York will be presented at the Academy of Medicine, Rochester, New York, on Thursday, April 15, 1943. The meeting will be called to order at 4:15 P.M., with Dr. J. Craig Potter as Chairman. The following papers will be presented:

Opening Remarks. G. Kirby Collier, M.D., Rochester, N. Y.

Care of the Advanced Cancer Patient. Norman Treves, M.D., New York, N. Y.

What May Logically Be Expected from Pre- and Postoperative Irradiation in Mammary Cancer. Fred W. Stewart, M.D., New York, N. Y.

Dinner will be served at 6:30 P.M. at the Academy of Medicine. Reservations are required in advance. It is requested that those planning to attend cooperate with the committee by sending their reservations to Dr. J. Craig Potter, Academy of Medicine, 1441 East Avenue, Rochester, N. Y.

The program will be resumed in the evening at 8 P.M., with Dr. Leo F. Simpson as Chairman, and the following papers will be presented:

Opening Remarks. John Aikman, M.D., Rochester, N.Y.

Rôle of the Endocrines in Neoplastic Disease. Cornelius P. Rhoads, M.D., New York, N. Y.

Diagnosis and Treatment of Prostatic Cancer. Charles B. Huggins, M.D., Chicago, Ill.

AMERICAN BOARD OF RADIOLOGY

The next examination of the American Board of Radiology will be conducted on June 3, 4 and 5, 1943, at the Palmer House in Chicago.

This examination precedes the Teachers' Conference of Radiology and the annual meeting of the American College of Radiology for members, Fellows and guests, to be held on Sunday, June 6 at the Palmer House.

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

ROENTGENOGRAPHY OF THE EXTERNAL EAR

By MAJOR ARTHUR W. FUCHS, *Sanitary Corps*
Army Medical School
WASHINGTON, D. C.

PLASTIC surgeons are frequently confronted with the problem of reformation or plastic repair of the external ear in cases of military or non-military mutilation, congenital malformation or abnormal projection. Surgical correction can be facilitated in some measure by information provided by the roentgenologist for the roentgenogram can depict the form and character of many traumatic and pathological alterations. The size and form of the concha and the character of its cartilages can be visualized as well as incipient or advanced calcification caused by systemic, circulatory or senile changes, malnutrition or frostbite. Since the surgeon is interested in the progress made by the patient after restorative work is completed, follow-up roentgenograms can be distinctly of service.



FIG. 1. *1*, helix; *2*, fossa triangularis; *3*, crus antihelicis superior; *4*, scapha; *5*, crus antihelicis inferior; *6*, cymba conchae; *7*, tuberculum auriculare; *8*, crus helicis; *9*, tragus; *10*, cavum conchae; *11*, antihelix; *12*, incisura intertragica; *13*, antitragus; *14*, lobule; *15*, external acoustic meatus.

The anatomy of the external ear in addition to a useful roentgenographic technique for recording the auricle is herein described.

ANATOMY

The external ear (Fig. 1) is a shell-shaped organ known as the auricle (auricula) which is attached to and projects from the lateral aspect of the head. In the most depressed portion is located the *external acoustic meatus* (*15*) which forms the entrance to the canal leading to the tympanic membrane.

The auricle presents lateral and medial aspects and forms an angle of approximately 30 degrees with the side of the head. The lateral surface is irregularly concave and exhibits several prominent elevations and depressions. The medial aspect is somewhat irregular and the elevations on its surface correspond to the depressions in the lateral aspect. The deepest depression is divided by a transverse ridge (*crus helicis*) (*8*) into an upper (*cymba conchae*) (*6*) and a lower portion (*cavum conchae*) (*10*). Anteriorly, the crus helicis is continuous with the auricular border (*helix*) (*1*) which is incurved and forms the outer limit of the auricle. In the upper portion of the descending helix, a small tubercle (*tuberculum auriculare*) (*7*) occurs. Anteriorly to the descending helix is a second elevation (*antihelix*) (*11*) which is single below but divides

superiorly into a superior (*crus antihelicis superior*) (3) and an inferior ridge (*crus antihelicis inferior*) (5) between which is a triangular depression (*fossa triangularis*) (2). The *scapha* (4) is an elongated depression between the helix and the antihelix.

The concavity of the concha is overlapped anteriorly by the *tragus* (9) and posteriorly by the *antitragus* (13); the notch between these processes is the *incisura intertragica* (12). The *lobule* (14) is situated below the incisura intertragica and is the most dependent part of the auricle.

The auricle varies in size and shape, usually being smaller and more finely modeled in the female than in the male. It consists largely of two layers of thin skin and an intricately shaped lamella of yellow fibrocartilage which gives form to the ear; the lobule is composed essentially of fat and connective tissue. The cartilage of the auricle is attached to the temporal bone by an anterior and a posterior ligament and a series of extrinsic and intrinsic muscles.

Prominent ears are fairly common and usually are caused by incomplete development of the antihelix. The condition is generally bilateral but it occasionally occurs on one side only. Ears may be of different sizes and not on the same level. Congenital absence occurs about 1 in 20,000.

TECHNIQUE

The location of the external ear makes it difficult to roentgenograph when employing a cassette or exposure holder. However, the occlusal film in its packet because of its size ($2\frac{1}{4}$ by 3 in.) and shape offers a most convenient vehicle for recording easily the image of the external ear.

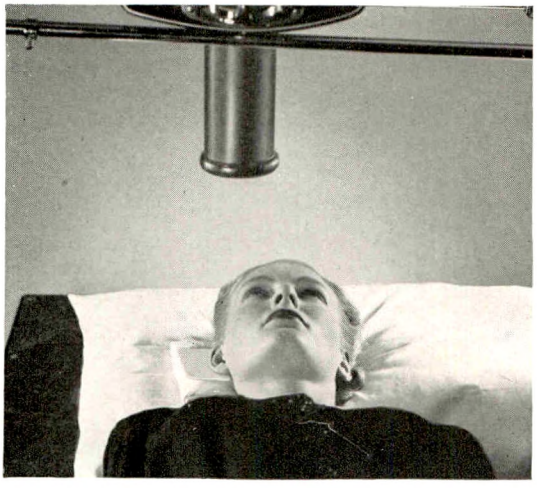
In roentgenography of the external ear the patient lies supine on the table with the head on a pillow and the median plane is vertical. The ear is gently bent forward and placed on an occlusal film packet which is supported by a small sandbag so that the plane of the film is horizontal. The medial edge of the packet is butted to the lateral aspect of the head. The central ray is projected perpendicularly through the center of the ear and tangentially to the lateral aspect of the head (Fig. 2 and 3).

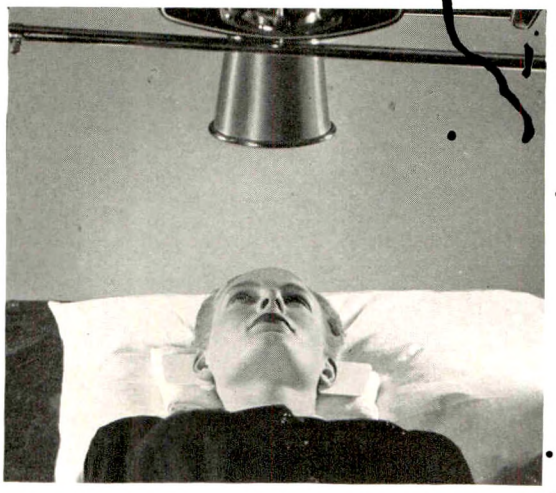
Views of both ears may be made with one exposure by arranging an occlusal film under each ear. The central ray is then projected in the intersection of a transverse plane passing through the centers of both ears, and the median plane (Fig. 4 and 5). A small amount of the soft tissues of the lateral aspect of the head is projected and superimposed on the medial aspects of the ears but the quantity is not sufficient to interfere with interpretation. The technique most suitable for roentgenography of the ear is described briefly and more completely as follows:

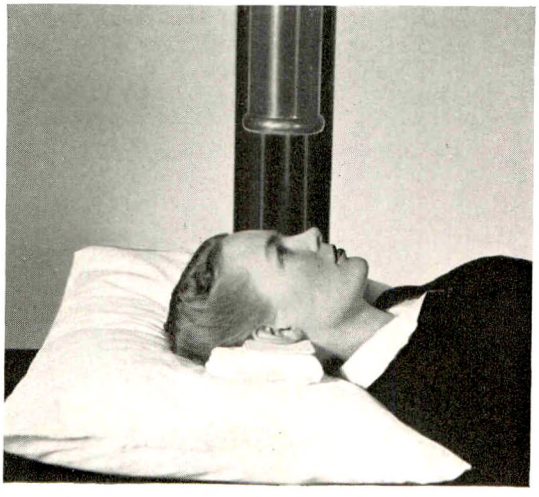
Region.	External ear.
Projection.	Anterolateral.
Localization Point.	Center of ear.
Film Placement.	Long axis of horizontally aligned film packet (($2\frac{1}{4}$ by 3 in.) coincident with long axis of ear; film packet placed posterior to projecting ear and supported by small sandbag so that plane of packet is horizontal; medial edge of packet butted against lateral aspect of head; center of ear over approximate center of packet (Fig. 2 to 5).
Posture.	Patient supine; head on pillow; chin depressed and ear gently bent forward so that long axis is horizontal and placed on supported film packet (Fig. 2 to 5).
Projection Central Ray.	The central ray is projected perpendicularly to plane of film (1) for one ear, through center of auricle and tangential to lateral aspect of head—3 in. cone is used (Fig. 2 and 3); (2) for both ears, in intersection of a transverse plane passing through the centers of both ears, and the median plane—4 in. cone is used (Fig. 4 and 5).
Roentgenogram.	Shows cartilages and soft tissues of the external ear (Fig. 6).

Technical Factors.

Kv. (peak) (optimum)	40	Focal spot	Small
Ma.	5	Cones	3 in. and 4 in.
Anode-film distance	30 in.	Filter	0.5 mm. Al
Film Occlusal, super-speed			







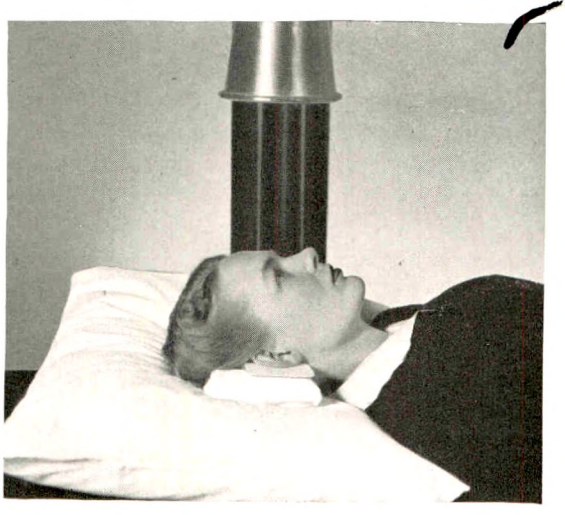


FIG. 2 (upper)
FIG. 3 (lower)

FIG. 4 (upper)
FIG. 5 (lower)

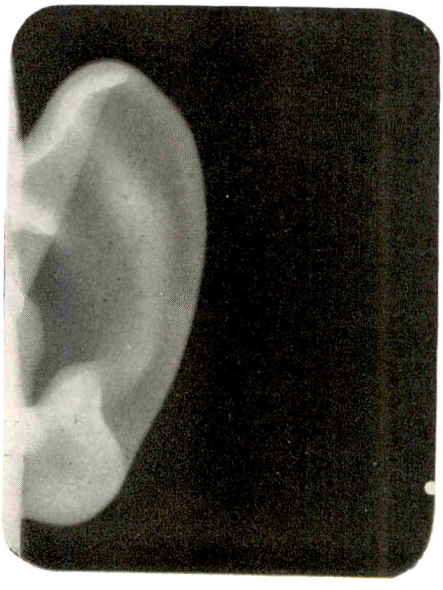


FIG. 6

In those cases where it is impossible to bend the ear due to lack of flexibility or to injury, the film packet is placed between the ear and the head with the patient in the lateral recumbent position. In this instance the central ray is directed at the external acoustic meatus.

The occlusal film packets are covered with white paper that are pebbled on the tube side. They are obtainable in two speeds—*super-speed* and *regular*. The former type is double coated and requires only one-eighth the exposure necessary for the regular film which is single coated.

The references appended represent a fairly comprehensive survey of the literature from a roentgenographic standpoint. An excellent bibliography is given with the paper by Higbee.[12]

REFERENCES

1. Bruch, E. Bilateral ossification of external ear. *Ztschr. f. Laryng., Rhin., Otol.*, 1934, *25*, 434–435.
2. Childrey, J. H. Bony deposits in the auricle. *Arch. Otolaryng.*, 1937, *25*, 473–474.
3. Davis, A. D. Plastic surgery of the ear, nose, and face. *Arch. Otolaryng.*, 1929, *10*, 575–584.
4. Davis, J. S., and Kitlowski, E. A. Abnormal prominence of the ears; method of readjustment. *Surgery*, 1937, *2*, 835–848.
5. Desfosses, P. Les oreilles. *Presse méd.*, 1930, *38*, 681–683.
6. Eisenklam, J. Plastic surgery of large ears. *Wien. klin. Wchnschr.*, 1930, *43*, 1176.
7. Eitner, E. Plastic reconstruction of the auricle. *Deutsche Ztschr. f. Chir.*, 1934, *242*, 797–801.
8. Franekel, E. Calcification and ossification of external ear. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1919–1921, *27*, 253–258.
9. Fraser, J. S., and Davis, E. D. D. Mal-developments of the auricle, external acoustic meatus and middle ear. *Proc. Roy. Soc. Med.* (*Sect. Otol.*), 1929, *22*, 85–96.
10. Frindenberg, P. A propos d'oreilles; l'épicanthus auriculaire. *Presse méd.*, 1931, *39*, 584.
11. Heermann, H. Zur Frage der Plastik bei Gehörgangsradikaloperationen. *Ztschr. f. Hals-, Nasen-, u. Ohrenh.*, 1930, *26*, 35–41.
12. Higbee, D. R. Calcigerous metaplasia of auricular cartilage. *Arch. Otolaryng.*, 1931, *14*, 70–79.
13. Hörbst, L., and Loos, H. O. Ueber Elephantiasis der Ohrmuschel. *Arch. f. Dermat. u. Syph.*, 1932, *166*, 342–353.
14. Locard, E. Manuel de technique peliciere. Second edition. Payot, Paris, 1934. (See *Presse méd.*, No. 29, April 10, 1937.)
15. Lockwood, C. D. Plastic surgery of the ear. *Surg., Gynec. & Obst.*, 1929, *49*, 392–394.
16. MacCollum, D. W. The lop ear. *J. Am. M. Ass.*, 1938, *110*, 1427–1430.
17. Meltzer, P. Anatomy and physiology of the ear; review of literature from October, 1926, to October, 1927. *Arch. Otolaryng.*, 1928, *7*, 167–183.
18. Neumann, H. Zur Klinik der Perichondritis der Ohrmuschel und der Otitis externa diffusa. *Wien. med. Wchnschr.*, 1930, *80*, 125–126.
19. Padgett, E. C. Total reconstruction of the auricle. *Surg., Gynec. & Obst.*, 1938, *67*, 761–768.
20. Poth, D. O. Sex incidence of chondrodermatitis nodularis chronica helicis. *Texas State J. Med.*, 1937, *33*, 19–21.
21. Richter, Helmuth. Perichondritis of the external ear in the roentgenogram. *Ztschr. f. Hals-, Nasen- u. Ohrenh.*, 1927, *17*, 494–498.
22. Rigg, J. P., and Waldapfel, R. Plastic repair with cartilagoperiosteal bridge in drooping (or dog) ear. *J. Am. M. Ass.*, 1939, *113*, 125–126.
23. Scherrer, F. W. Calcification and ossification of external ears. *Ann. Otol., Rhin. & Laryng.*, 1932, *41*, 867–885.
24. Schmidt, H. Comedonensteine der Ohrmuschel. *Ztschr. f. Hals-, Nasen- u. Ohrenh.*, 1930, *26*, 549–550.
25. Straatsma, C. R. Congenital deformities of external ear; their mental effect. *Arch. Otolaryng.*, 1930, *11*, 609–613.
26. Vollmer, H. Shape of ear in relation to body constitution. *Arch. Pediat.*, 1937, *54*, 574–590.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Skeletal System

NATHANSON, L., and COHEN, W.: A statistical and roentgen analysis of 200 cases of bone and joint tuberculosis 425

KNUTSSON, F.: Roentgenology of the femoropatellar joint and a good projection for the knee joint 425

MENSOR, M. C., and MELODY, G. F.: Osteochondritis dissecans of the ankle joint ... 426

LICHT, E. DE F.: On bipartite os naviculare pedis 426

SANFORD, H., and DOUB, H. P.: Epidurography 426

BUNTS, A. T.: Surgical aspects of ruptured intervertebral disc 426

SGALITZER, M.: Roentgenographic diagnosis of vertebral syphilis 427

GHORMLEY, R. K., and ADSON, A. W.: Hemangioma of vertebrae 427

KRAUSE, G. R., and LANGSAM, C. L.: Fractures of the vertebrae following metrazol therapy 428

BANKS, S. W.: Aseptic necrosis of the femoral head following traumatic dislocation of the hip 428

ROENTGEN AND RADIUM THERAPY

GOIN, L. S., CROSSAN J. W., and JELLEN, J.: Low-voltage contact roentgen therapy (Chaoul therapy) 429

GOIN, L. S., and HOFFMAN, E. F.: Use of intravesical low-voltage contact roentgen irradiation in cancer of the bladder 429

PENDERGRASS, E. P., and HODES, P. J.: Further experiences with Chaoul therapy 430

KAPLAN, I. I.: Irradiation of brain tumors at Bellevue Hospital 1924–1929 430

MANDEVILLE, F. B., RUSSELL, D. A., and FARLEY, M. S.: Roentgen therapy of 100 consecutive tumors of the brain or spinal cord 431

ROBERTS, F.: Breast cancer 431

LEUCUTIA, T., WITWER, E. R., and BELANGER, G.: Late results in benign giant-cell tumor of bone obtained by radiation therapy ... 431

MISCELLANEOUS

WILSON, C. W.: Some geometrical methods of projecting dose contours 432

BINKS, W.: Nomogram for determination of lead protection against high-voltage x-rays 432

VOL. 49, NO. 3

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

NATHANSON, LOUIS, and COHEN, WILLIAM. A statistical and roentgen analysis of two hundred cases of bone and joint tuberculosis. *Radiology*, May, 1941, *36*, 550–567.

Two hundred cases of bone and joint tuberculosis from the Sea View Hospital, Staten Island, New York, are analyzed. One hundred of them were children up to sixteen years of age and the other hundred were adults from sixteen to seventy years of age. Tables are given showing the distribution of cases according to sex, age and race, the comparative distribution of the lesions in the children's and adult groups, the distribution of multiple lesions and the complicating conditions.

The most frequent site of the tuberculosis was in the spine. In the adult group there was a definite preponderance of tuberculosis in weight-bearing areas while this was less marked in the younger group. This is probably due to the influence of trauma and physical exertion in adults and to early post-primary hematogenous dissemination in the children's group. All the cases of tuberculosis of the long bones were in children. Involvement of more than one bone was common.

These bone lesions were frequently complicated by pulmonary tuberculosis, pleural effusion and amyloidosis.

On roentgen examination paravertebral abscess can frequently be demonstrated. It may be the only roentgen sign of the disease. It may be seen best on the lateral roentgenogram. Involvement of separate areas of the spinal column, or skipped infection, is not infrequent. But often on autopsy the intervening segments were found involved also. Any part of the body of the vertebra may be involved. Marginal localization of the tuberculosis is more frequent in adults than in children. The proximity of these lesions to the periosteum probably causes the pain so frequently seen in adults. In children the center of the vertebra is more frequently involved; the center of the body may give way, resulting in gibbus formation.

Tuberculosis of the shaft of long bones in children may simulate diffuse, chronic, nonspecific osteomyelitis or a punched out cystic type of lesion. The shaft is frequently involved secondary to joint tuberculosis.

Though tuberculosis of bone is commonly thought to be purely destructive considerable productive bone reaction was seen in these cases. The productive periostitis is nearly always parallel to the shaft. Tuberculosis of the shaft of the short bones of the hands and feet is frequent in children and rare in adults. Flat bones are rarely affected by tuberculosis. Punched-out lesions were so frequently seen in the shaft of long bones immediately adjacent to tuberculosis of the joints that this sign is considered valuable in diagnosis. Bilateral symmetrical lesions were seen and indicate that the involvement is hematogenous.

Bone and joint tuberculosis are so similar to many other bone lesions that diagnosis cannot be made from the roentgenogram alone but the clinical facts must be studied carefully.—*Audrey G. Morgan.*

KNUTSSON, FOLKE. Über die Röntgenologie des Femoropatellargelenks sowie eine gute Projektion für das Kniegelenk. (The roentgenology of the femoropatellar joint and a good projection for the knee joint.) *Acta radiol.*, 1941, *22*, 371–376.

A complete examination of the knee joint requires an axial as well as a frontal and lateral projection. Heretofore the axial projection has generally been taken with the knee flexed at a right angle which does not make it possible to judge the thickness of the cartilage or the condition of the patellar surface of the femur.

The author describes and illustrates a new position for the axial projection. The patient lies on his back on the table with a pillow under the knee which brings about a flexion of 130°–150°. The patella lies in its groove on the patellar surface of the femur and it is possible to study various degrees of lateral subluxation of the patella and to see every detail of any changes caused by arthritis deformans. Such changes when localized only in the knee joint may be caused by varying degrees of dysplasia of the femoropatellar joint.—*Audrey G. Morgan.*

MENSOR, MERRILL C., and MELODY, GEORGE F. Osteochondritis dissecans of the ankle joint; use of tomography as diagnostic aid. *J. Bone & Joint Surg.*, 1941, *23*, 903–909.

In the literature at their disposal, the authors found only 17 cases of osteochondritis of the ankle joint, and to their knowledge there are reports of but 2 other established cases, the published accounts of which were not accessible to them. They report an additional case which is reported mainly because of two factors: first, it is another established instance of osteochondritis of the ankle joint; second, it illustrates the value of tomography in the roentgenographic diagnosis of lesions of the osseous system, and emphasizes its importance in the accurate localization of bone defects requiring operative intervention. By this means it is possible to plan preoperatively the most direct approach whereby the lesion can be reached with a minimum of trauma to the surrounding structures.

The patient was a male, aged thirty-four, and was first seen eight months after he had sustained an injury to the right ankle joint, resulting from a fall from a platform, 8 feet high. By means of the tomograph, the osteochondritic process was localized on the superior articular surface of the talus.

Chronic pain or discomfort in the ankle—following a sprain, dislocation or fracture—which persists despite ordinary conservative treatment should suggest the possibility of osteochondritis dissecans tali. A history of recurrent instability of the ankle joint should arouse suspicion relative to the possibility of a loose fragment or "joint mouse." Mensor and Melody regard arthrotomy as the treatment of choice, with removal of the fragment or fragments, but without immobilization. This should be followed by rehabilitation therapy in the form of diathermy, massage, and graded exercises, which are important adjuncts in the accomplishment of prompt postoperative recovery of normal function and complete rehabilitation. Prognosis is excellent in patients receiving early diagnosis and appropriate treatment. Such treatment is also a prophylaxis against the development of chronic hypertrophic synovitis and traumatic arthritis.—*R. S. Bromer.*

LICHT, ERIK DE FINE. On bipartite os naviculare pedis. *Acta radiol.*, 1941, *22*, 377–382.

The author describes the first 4 cases of bipartite navicular bone of the foot that have been recorded in Denmark. They are illustrated with roentgenograms. In all of these cases there was more or less arthritis of the joints involved. This has not been true in the cases previously published but they were all in young subjects, while the author's youngest patient was forty-six years of age when first examined. In 2 of the cases the condition was bilateral. In 1 of the cases the patient had been examined nine years before and the new roentgenograms showed considerable progress in the arthritis. In 1 of the cases the appearance was typical on one side, while on the other it was not completely developed.

Differential diagnosis from tabes and fracture must be considered. The author believes that this is a congenital malformation. The treatment must be orthopedic.—*Audrey G. Morgan.*

SANFORD, HAWLEY, and DOUB, HOWARD P. Epidurography. *Radiology*, June, 1941, *36*, 712–716.

Epidurography is presented as a new method of demonstrating protrusion of the intervertebral discs. The air is injected into the epidural space instead of the subarachnoid space. It is the logical method as the disc protrudes directly into the epidural space. The space is closed at the top at the foramen magnum and no air passes into the skull. Therefore the patient can be seen for further diagnostic studies the same day. This also prevents the headache and discomfort caused by air myelography. The technique of the method is described and illustrated and epidurograms given of a normal spine and one with a protrusion of a disc. In a study of 77 cases it was found that roentgenographic diagnosis could be made by epidurography alone without subsequent use of lipiodol in 55 per cent of the cases and with the air myelogram in only 35 per cent.—*Audrey G. Morgan.*

BUNTS, A. T. Surgical aspects of ruptured intervertebral disc; with particular reference to thorotrast myelography. *Radiology*, May, 1941, *36*, 604–616.

Patients who complain of lumbago, recurrent sciatica, lumbosacral strain or sacroiliac arthritis frequently have a ruptured intervertebral disc. These may be demonstrated by contrast myelograms. The author prefers thorotrast to lipiodol as a contrast medium, as it is less viscous and fills the sheaths of the spinal nerves

more completely. For the same reason it can be removed almost completely from the subarachnoid space by forced drainage and the small amount left gives off much less than the minimal toxic levels of radiation. When ruptured intervertebral disc is demonstrated it must be removed surgically. Sometimes this requires only partial removal of bone from one side of the laminae, sometimes removal of the entire laminae of two vertebrae; occasionally it can be removed without any bone destruction. The nerve root should be free of pressure when the operation is completed.

Twelve cases are described and illustrated with myelograms. The conditions found at operation are compared with the myelographic picture. In 2 cases the history and physical examination suggested tumor of the cauda equina.

The roentgenologist should be present in the operating room to learn the exact anatomical picture presented and be able to compare it with his myelographic findings.

In the discussion Dr. Camp said that he believed that thorotrast was satisfactory if there was no question of a tumor higher up in the spinal canal. Thorotrast as used by Dr. Bunts shows only the lower three segments of the lumbar canal. It is possible for patients with tumor in the cervical and thoracic parts of the spinal canal to have low back pain; this occurs in about 30 per cent of patients with tumors in the cervical canal and about 50 per cent of those with tumors in the thoracic canal. Thorotrast is also an intense irritant to the subcutaneous tissues. The lateral and prone oblique positions should be used in order not to miss a central type of protrusion.

Dr. Bunts replied that in cases in which they suspected tumor they had been injecting lipiodol into the cistern and allowing it to flow down the canal, while in cases in which herniation of a disc was suspected they had been using thorotrast.—*Audrey G. Morgan.*

Sgalitzer, Max. Roentgenographic diagnosis of vertebral syphilis. *Radiology*, July, 1941, *37*, 75–78.

Three cases of vertebral syphilis are described in all of which there was intense pain and in all the destructive lesions were localized in the cervical spinal column, being found in 2 of the cases in the upper and middle cervical vertebrae. Though there had been extensive destruction of the bodies of one or more of the vertebrae there was no collapse, because of marked sclerosis and hyperostosis. There was no wedging of the bodies of the vertebrae and no changes in the intervertebral discs. The destruction was chiefly in the ventral part of the bodies of the vertebrae, the borders of which were irregularly indented. This is caused by penetration of the syphilitic granulation tissue into the bone, forming rough cavities with indented borders. This form of destructive syphilitic spondylitis can be readily differentiated in the roentgenogram from other forms of bone disease, though spondylitis syphilitica simplex cannot.

It differs from tuberculosis in the fact that osteosclerosis predominates, while in tuberculosis decalcified areas appear at an early stage. The bodies of the vertebrae collapse early in tuberculosis and wedge formation occurs. The intervertebral discs are frequently destroyed in tuberculosis. Cold abscesses are found in tuberculosis while there are no abscesses in this form of syphilis. In osteomyelitis there is decalcification, wedge formation and abscess. Lymphogranulomatosis also shows decalcification, with osteosclerosis only in the healing stage. Osteoplastic tumor metastases extend over larger parts of the spinal column; the bodies of the vertebrae break down.

The diagnosis is confirmed by the results of antisyphilitic treatment. The importance of early roentgen diagnosis is shown by the first case described above. This patient had wandered from doctor to doctor for twenty years without relief from the intense pain. He recovered promptly on antisyphilitic treatment.—*Audrey G. Morgan.*

Ghormley, Ralph K., and Adson, Alfred W. Hemangioma of vertebrae. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 887–895.

Ghormley and Adson state that evidence points toward vertebral hemangioma as a definitely recognizable condition which often does not produce symptoms. However, the symptoms of some patients, particularly the younger ones, may be marked, even to development of complete paraplegia. In such cases laminectomy with decompression, followed by roentgen therapy, offers the best possibility of relief. In patients in whom paraplegia is not present but in whom there is evidence of compression of the spinal cord or local symptoms, roentgen therapy is the treatment of choice. Supportive corsets

or braces should be used whenever they are indicated, for instance with patients who have the static type of pain or sufficient involvement of the vertebra by the hemangioma to cause a pathological compression fracture. This latter complication is rarely noted, however.

Roentgenographic studies of the involved portion of the spinal column usually reveal pathognomonic evidence of the disease. Studies in the earlier phase will reveal areas of hypertrophy of the pedicle and lamina, enlargement of the intertrabecular spaces, and absorption of trabeculae in the body, with thickening of other trabeculae, thus giving the appearance of channels situated between or interwoven among the trabeculae. In the more advanced stages of the disease, a ballooning process takes place, the body of the vertebra is flattened and the walls have a tendency to bulge. This process accounts for the narrowing of the spinal canal. In a few instances, a pathological fracture has occurred, with accounts for the kyphosis or scoliosis.

Roentgen treatment consisted in irradiation of the affected vertebra through four posterior portals. Each field received a dose of approximately 500 r. The factors used were as follows: 135 kv., at a distance of 16 in. (40.6 cm.), 5 ma., and 6 mm. of aluminum filtration. This dose was repeated at intervals of four to six weeks for three to four treatments and thereafter once or twice a year over a period of four years. The number of treatments depended on the findings on clinical and roentgenographic examination.—*R. S. Bromer.*

KRAUSE, GEORGE R., and LANGSAM, CHARLES L. Fractures of the vertebrae following metrazol therapy. *Radiology*, June, 1941, *36*, 725–730.

The authors studied a group of 75 patients treated with metrazol in the Neuropsychiatric Division of the Cleveland City Hospital. Thirty-two of them, or 42.6 per cent, suffered fracture of one or more vertebrae, an average of more than two per patient as there were 70 fractures in all. The fractures were seen most frequently in the mid-thoracic spine, indicating that the injury is caused by the flexion that occurs during the convulsion.

This is so high a percentage of injury that it makes metrazol an unsafe drug; moreover the efficacy of the drug has not yet been proved beyond question and it should only be used in selected cases. Of the 7 patients in this group who had osteoporosis 5 sustained fractures. Therefore osteoporosis should be ruled out by roentgen examination before metrazol treatment is given. Routine roentgenograms should be made before and after metrazol therapy. It is possible that some such drug as curare, which acts on the muscle-nerve end plate might prevent some of these fractures.—*Audrey G. Morgan.*

BANKS, SAM W. Aseptic necrosis of the femoral head following traumatic dislocation of the hip. *J. Bone & Joint Surg.*, Oct., 1941, *23*, 753–781.

Banks collected 42 cases of aseptic necrosis of the femoral head after traumatic dislocation of the hip, and to these, reported in the literature, he adds 9 cases. The recovery of a normal range of motion and freedom after reduction of a traumatic dislocation of the hip and a short period of cast or traction immobilization, is generally accepted as evidence of complete recovery. In such instances, the patient is then permitted to bear full weight on the limb and to return to his occupation with the understanding that he is cured. This encouraging prognosis is not a safe one, for many of these individuals experience a recurrence of pain and progressive disability of the hip after months or, exceptionally, years of normal activity and unchanged roentgenograms. This reappearance of symptoms after an early period of apparent recovery is now known to be due to aseptic necrosis of the head of the femur, which had resulted from a disruption of a major portion of its blood supply at the time of the dislocation.

The blood supply of the head of the femur in the adult is derived from the nutrient branches of the anterior and posterior circumflex arteries which enter the epiphysis after passing through the capsule on the neck, and from the arteries of the round ligament. Banks states that further observations and especially pathological studies are necessary to prove which of these two sources of supply when injured are the cause of the avascularity of the head.

The histopathological alterations in the head, when it undergoes avascular necrosis and replacement following dislocation of the hip, appear to be similar to those seen, and confirmed by pathological examination, in necrotic heads after fractures of the neck of the femur followed by bony union. Ordinarily, three to four months are required for sufficient atrophy to occur before contrast between living and dead bone is distinguishable in roentgenograms. Marked disuse atrophy of the adjacent living bone of the

shaft and pelvis usually occurs following the injury and immobilization. Since the necrotic head without its blood supply cannot participate in the decalcification, it will retain its original density and cast a shadow of greater intensity in the roentgenograms than will the surrounding living bone. This becomes apparent after three or four months and, succeeding this, late evidence of necrosis may develop as shown in the roentgenograms in the form of progressive replacement of avascular dense bone by less dense, irregular, living bone, alterations in the shape of the head following collapse or fragmentation, or signs of a deforming arthritis.

Banks emphasizes the importance of early diagnosis in order that the devitalized head may be adequately protected from weight-bearing during its revascularization and replacement by new bone. He recommends that whenever possible the extremity be protected from weight-bearing by means of crutches for four to six months after the post-reduction period of immobilization or recumbency. If the femoral head undergoes uniform atrophy of disuse and no density difference develops between it and the then osteoporotic living bone of the shaft and ilium as shown by roentgenograms, the patient may resume full weight-bearing with the likelihood that the head has remained alive, although the roentgenographic follow-up should continue for an additional twelve months. However, if the head is shown to be necrotic, early protection can be provided and continued until serial roentgenograms show final revascularization and replacement by new bone.

On the other hand, if the patient insists on walking six weeks after the dislocation without the aid of crutches, roentgenographic examination of the hip must be obtained at intervals over a period of at least two years, although the extremity may appear clinically intact. When the diagnosis becomes available before much damage to the head has occurred, weight-bearing should be prevented until replacement has been completed. If, however, the hip is already the site of a marked deforming arthritis which precludes the possibility of a satisfactory outcome, an arthrodesis appears to be indicated.—*R. S. Bromer.*

ROENTGEN AND RADIUM THERAPY

GOIN, LOWELL S., CROSSAN, JOHN W., and JELLEN, JOSEPH, Low-voltage contact roentgen therapy (Chaoul therapy). *Radiology*, May, 1941, *36*, 583–587.

There is considerable evidence to support the theory that the biological effect of irradiation is not dependent on wave length. Based on this assumption Chaoul and Adam experimented with methods of using low-voltage irradiation under conditions that would give the same effect as radium irradiation. The necessary conditions for this are a short distance between the surface and the source of radiation with a consequent absorption of a large amount of energy in the first few centimeters of tissue.

The authors describe and illustrate the Philips Metalix Contact Therapy unit which fulfills these conditions. It operates with 50 kv. potential and 2 ma. current. The depth dose tables and figures for backscatter which are given show that the combination of short anode-surface distance and soft radiation makes it possible to closely approximate the ideal of maximum damage to tumor cells and minimum injury to normal tissues. The anode-surface distance is only 22 mm. which may be increased to 42 mm. by the use of a localizing cylinder with a cuff. By means of the localizing cylinders the tube can be fitted directly over a superficial lesion to be treated. In some cases the authors have given a dose of as much as 30,000 r to an area of 6 sq. cm. given in fractions of 2,500 r on alternate days. The reactions are earlier and less painful than those of the usual treatment.

The ease of application, the short treatment time and the comparatively mild reaction make this an ideal treatment for cancer of the skin or in body cavities that are accessible or can be rendered so by surgery. It is not adapted of course to the treatment of deep lesions.—*Audrey G. Morgan.*

GOIN, LOWELL S., and HOFFMAN, EUGENE F. The use of intravesical low-voltage contact roentgen irradiation in cancer of the bladder. *Radiology*, Nov., 1941, *37*, 545–549.

There is a group of bladder tumors involving the trigone, one or both ureteral orifices and the neck of the bladder in which the only possible treatment heretofore has been total cystectomy. The authors previously described a method in which they marsupialized the bladder and gave a series of treatments with a roentgen tube introduced into the bladder and in contact with the lesion. They now prefer cystotomy repeated two or three times. This reduces the necessary hospitalization to two to four weeks as compared with six or seven with marsupialization. Complete visual control of the application of the roentgen tube is possible and only two or three anesthesias are required instead of ten to

fifteen. The amount of radiation given each time is increased but the total amount is decreased.

Under spinal anesthesia the patient is catheterized and the bladder opened. The roentgen tube, covered with a sterile piece of stockinet and a thin sterile rubber sheath, is inserted into the wound and its end brought in contact with the tumor. Half the dose is given and the tube removed and the field inspected to see that the rays are being directed properly. Then the tube is reinserted and the rest of the treatment given. The usual dose is 7,668 r, 1,278 r per minute, 50 kv. constant potential, 2 ma., anode-surface distance 2.5 cm., half-value layer, 1.0 mm. aluminum. The wound is closed with a catheter left in place. Seven to ten days later the second treatment is given and if necessary as shown by the findings a third is given seven to ten days after that. For the first three months after operation the bladder is irrigated with potassium permanganate, a urinary antiseptic given and the urine acidified to prevent encrustation of the sloughing area. Cystoscopic inspection should be made every three months for a year and every six months after that for four or five years.

There has been no surgical mortality in the authors' cases and in the series of 13 cases which is reported in the form of a table cystoscopy has shown in all but one total disappearance of the tumor from six to eighteen months after treatment. In one case the malignant growth persists.

In reply to a question as to the type of tumor in which this method is indicated Dr. Goin replied that it should be limited to tumors of the trigone not more than 3 cm. in diameter. Nor should it be too small, for very small tumors of low grade malignancy can be treated through the urethra which is easier and safer and less expensive for the patient.—*Audrey G. Morgan.*

Pendergrass, Eugene P., and Hodes, Philip J. Further experiences with Chaoul therapy. *Radiology*, Nov., 1941, *37*, 550–559.

In 1937 the authors described 80 cases treated with short distance, low voltage roentgen therapy, using a Chaoul unit. Since then they have treated a much larger number of cases. The Chaoul unit is very flexible and particularly adapted for treating small tumors about the eyes and nose. Large amounts of radiation can be given to small volumes of tissue. The lesion must be accessible. Because of the rapid decrease in depth dose by this method it should not be used for lesions more than 1.5 to 2 cm. in thickness. Nor should the lesions be too large. For large lesions multiple portals must be used which involves the danger of over-irradiating some areas and under-irradiating others. For such lesions it is probably best to use intermediate voltages and short target-skin distances. Cartilage does not seem to tolerate this form of treatment well.

From February, 1936, to September, 1940, the authors have used this method in the treatment of 228 malignant tumors, 106 benign tumors and 207 inflammatory conditions. They discuss details of technique in different conditions, illustrating them with actual cases treated. They advocate basing the total dosage on the reaction of the tissues to the irradiation. This avoids under-dosage of the more resistant parts of the tumor and minimizes the danger of later indolent ulcerations.—*Audrey G. Morgan.*

Kaplan, Ira I. Irradiation of brain tumors at Bellevue Hospital 1924–1929. *Radiology*, May, 1941, *36*, 588–595.

This article is based on a series of 154 brain tumors treated by irradiation at Bellevue Hospital. Excluding pituitary tumors there was a total of 115 cases, 10 of which were of the cerebellum.

Irradiation is of undoubted value in the treatment of tumors of the brain. It is very effective in gliomas and may be used effectively even in slow-growing tumors. Formerly too small doses were used for fear of damaging normal tissue but it has been found that if properly given very large doses can be used as the tissue of brain tumors is much more radiosensitive than normal brain tissue.

As a rule, treatment is given with high-voltage roentgen rays or the radium pack. Generally irradiation should follow surgical exploration to determine the nature of the tumor, and decompression, because irradiation tends to cause hyperemia and edema. Skill and experience is required in the radiotherapy of brain tumors for there is danger of coma and even death if treatment is not properly given.

Roentgen treatment is generally given with 200 kv., a filter of 0.5 mm. copper and 1 mm. aluminum at a distance of 40 to 50 cm. with four to eight fields. Treatment is given daily in doses of 100 to 300 r to one or more fields; the

total dose is 1,000 to 1,500 r to each field in each series. In some cases a total dose of 42,000 r was given over a period of months. For radium therapy the 5 gram radium pack was used, delivering 5,000 milligram-hours of irradiation at 6 cm. distance, filtered through 2 cm. platinum. From four to eight fields may be used, each being given a dose of 10,000 to 50,000 milligram-hours over a period of several days or weeks.

Irradiation is effective in the treatment of pituitary tumors and hyperplasia of the pituitary. The author believes that with the use of large doses tumors that have been considered radioresistant will be brought into the radiosensitive class. Illustrative cases of glioma and pituitary tumor that were treated successfully are described.

In the discussion the fact was brought out that not more than 6,000 r should be administered to brain tissue in any one series of treatments.—*Audrey G. Morgan.*

Mandeville, F. B., Russell, D. A., and Farley, Maude S. Roentgen therapy of 100 consecutive tumors of the brain or spinal cord. *Radiology*, Nov., 1941, *37*, 560–568.

The authors discuss 100 cases of tumors of the brain or spinal cord in which they have given radiation therapy after surgical treatment consisting of decompression and partial extirpation. They have used a 200 kv. apparatus with a half-value layer of 0.8 to 2.0 mm. copper, an effective wave length of 0.16 to 0.12 Ångströms, 50 cm. target-skin distance, and large total daily doses of 400 to 800 r, measured in air. Four portals 10 cm. in diameter to the skull or two posterior oblique portals to the spine have been usual. Total doses in air to each portal have been from 700 to 1,200 r; occasionally 1,800 r has been given with smaller portals in pituitary cases and in spinal tumors with narrow fields.

The cycle has often been given in five days. They prefer to protract it to several weeks but the patients often refuse to cooperate. There are so many other factors in irradiation besides the total quantity, such as quality, spacing, portals, etc., that it is a mistake to consider dosage in terms of total quantity alone.

In this series of 100 cases, 34 of the patients have died, 16 have not been traced and 50 are still living. Only 7 of the patients cooperated completely and were given the treatment just as planned. All of these 7 are alive. The records show improvement or prolongation of life in all cases in which there was even partial cooperation.—*Audrey G. Morgan.*

Roberts, Ff. Breast cancer; a study of the train of events which may follow radical removal and post-operative x-ray therapy. *Brit. J. Radiol.*, Aug., 1941, *14*, 269–274.

Based on a careful study of 143 cases of his own the author concludes that some changes should be made in the usual routine treatment of cancer of the breast. In the first place he emphasizes the fact that this, like all cancer, does not long remain localized and it is the tendency to generalized dissemination that is the greatest problem in treatment. Recurrence is most frequent in the breast region, neck and skeleton and there is practically no recurrence in the axilla. Surgical removal of the axillary glands is complete and there are no glands in which the tumor can recur. Therefore irradiation of the axilla is superfluous, but the breast region and neck should be irradiated even more intensively than they have been. In the breast region low voltage should be used rather than high voltage because of the thinness of the chest wall and the possibility of injuring the lung. Because of the frequency of bone metastases the lower part of the spine and the pelvis should be given prophylactic irradiation.

Isolated recurrence is a sign of generalization and there is little use of treating the individual nodules as they appear. If there is localized persistent pain in the spine or pelvis, treatment should be given before roentgen signs of metastasis appear. Recurrence in the other breast occurs chiefly in young women and it does not make the prognosis particularly worse.—*Audrey G. Morgan.*

Leucutia, T., Witwer, E. R., and Belanger, George. Late results in benign giant-cell tumor of bone obtained by radiation therapy. *Radiology*, July, 1941, *37*, 1–17.

Formerly when giant cell tumors were considered true bone sarcomata the chief method of treatment was surgical. Since it has been found that they are benign roentgen treatment has become increasingly popular.

The authors study 33 cases treated at Harper Hospital, Detroit, from 1923 to 1935. A table summarizes the cases. In the first series from 1923 to 1929 curettage and postoperative irradiation were used. Amputation eventually

had to be performed in 3 of these cases and 1 resulted in sarcomatous degeneration and death. Of the 18 cases treated by irradiation alone after 1929 good results were obtained in all. They conclude that irradiation is to be preferred to surgery because it is simpler and does not harm normal tissues. With surgery there is danger of infection, the trabeculation of the bone is destroyed and reossification is delayed and the trauma of surgery may lead to malignant degeneration. These dangers are absent in radiotherapy.

When giant cell tumors were considered true neoplasms there was a tendency to give large doses of irradiation; now that they are known to be processes of inflammation and repair smaller doses are given. In the authors' cases treatment was given with 200 kv. equivalent (1 mm. copper forefilter). The initial dose was about 70 per cent S.U.D. reduced by about 10 per cent per series until treatment was completed. The full series was given at a single treatment, several fields being used for purposes of cross-firing. The series is repeated after two months and at gradually increasing intervals thereafter; the average time required for treatment is two years. With children smaller doses and longer intervals may be used: 50 per cent S.U.D. initial dose, three-month interval before the second series.

As the use of plaster casts after treatment led to demineralization from disuse, their use was discontinued. The patient is allowed to use the limb with crutches and cautioned to be careful in order to prevent fractures. The authors recommend radiation therapy as the treatment of choice in all giant cell tumors and related cystic bone conditions.

In the discussion Dr. Dickson objected that the authors had compared modern roentgen treatment with outmoded surgical treatment. He said their objections were valid in regard to curettage and the use of escharotics but did not apply to curettage and filling the cavity with bone chips, which is the modern surgical method.

Dr. Lenz said that giant-cell tumors around the knee were apt to be osteogenic sarcomas and that these should be operated on.

Dr. Newell said that in osteogenic sarcoma of the knee there was little chance of saving the patient's life by amputation and that with roentgen treatment there was much less danger of leaving severe deformity.

Dr. Leucutia said in closing that he did not want to give the impression that surgery was of no value but that even if a tumor of the knee were osteogenic sarcoma it was apt to be of the osteolytic or telangiectatic type and in these, too, roentgen treatment is indicated. If there is any doubt as to diagnosis a biopsy should be taken.—*Audrey G. Morgan.*

MISCELLANEOUS

WILSON, C. W. Some geometrical methods of projecting dose contours. *Brit. J. Radiol.*, Oct., 1940, *13*, 345–350.

The author describes a geometrical method of determining the distribution of radiation due to a single beam in any plane, no matter what the relation of the plane to the central axis of the beam. The explanation is illustrated by the isodose curves for the principal plane, that is the plane containing the central axis of the beam, and planes parallel to it and at distances of 1, 2 and 3 cm. from it, as these are the ones most commonly needed in practice. The method is perhaps more tedious than that with Mayneord's dose-contour projector but it may be useful in departments where the latter is not available. It is simple as it requires only the usual drawing instruments and materials.—*Audrey G. Morgan.*

BINKS, W. A nomogram for the determination of lead protection against high-voltage x rays. *Brit. J. Radiol.*, Sept., 1940, *13*, 322–323.

A nomogram is given for the determination of the amount of lead protection needed against roentgen radiation for voltages from 200 to 3,000 kv., for tube currents between 0.5 and 30 ma. and for distances between 0.5 and 10 meters when the tubes have reflection type targets and constant potential excitation. The method of using the nomogram is described.—*Audrey G. Morgan.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 APRIL, 1943 NO. 4

CONTENTS

Bleeding in Hiatus Hernia . . . . . OTTO D. SAHLER, M.D., AND AUBREY O. HAMPTON, M.D. 433

Bleeding Associated with Extramucosal Tumors of the Stomach . . . . OTTO D. SAHLER, M.D., AND AUBREY O. HAMPTON, M.D. 442

Secondary Lymphosarcoma of the Stomach . . . . . FRANZ BUSCHKE, M.D., AND SIMEON T. CANTRIL, M.D. 450

A Prenatal Diagnosis of Osteopetrosis . . . . . E. L. JENKINSON, M.D., W. H. PFISTERER, M.D., K. K. LATTEIER, M.D., AND MARY MARTIN, M.D. 455

Ghon's Tubercle . . . . . ROBERT G. BLOCH, M.D. 463

Ten Thousand Chest Examinations with the Stereoscopic Photoroentgen Unit . . . . . JOSEPH LEVITIN, LIEUTENANT COLONEL, M.C. 469

The Roentgenologic Diagnosis of Dilatations of the Spinal Cord Veins . . . . BERNARD S. EPSTEIN, M.D., AND LEO M. DAVIDOFF, M.D. 476

Experiences with Roentgen Irradiation following Operation on Brain Tumors . STUART N. ROWE, M.D., F.A.C.S., AND HAROLD W. JACOX, M.D. 480

Cancer of the Uterus . . . . . HARRY H. BOWING, M.D., AND ROBERT E. FRICKE, M.D. 487

The Elimination of Irradiation Injuries in the Treatment of Cancer of the Cervix . . . . . CHARLES L. MARTIN, E.E., M.D., F.A.C.R. 494

An Instrument for Inserting Multiple Capsules of Radium within the Uterus in the Treatment of Corpus Cancer . . . . . JAMES F. NOLAN, M.D., AND A. N. ARNESON, M.D. 504

Cancer of the Cervix . . . . . WILLIAM P. HEALY, M.D., AND GRAY H. TWOMBLY, M.D. 519

The Production and Characteristics of 3,000 Kilovolt Roentgen Rays . . . . . J. G. TRUMP, D.Sc., AND R. W. CLOUD, M.A. 531

Preliminary Clinical Observations on the Use of 3 Million Volt Roentgen Rays . . . . . RICHARD DRESSER, M.D. 536

Editorials

Megavoltage Roentgen Therapy 540

Joseph Francis Elward, 1890–1943 544

Society Proceedings, Correspondence and News Items 546

Book Reviews 549

Books Received 552

Department of Technique

Duplication of Roentgenograms by the Light Reversal Process . . . . GEORGE C. HENNY, M.D., GUSTAVUS C. BIRD, JR., M.D., AND HERBERT M. STAUFFER, M.D. 554

Abstracts of Roentgen and Radium Literature 556

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publisher.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 APRIL, 1943 No. 4

BLEEDING IN HIATUS HERNIA*

By OTTO D. SAHLER, M.D., *and* AUBREY O. HAMPTON, M.D.
BOSTON, MASSACHUSETTS

A STUDY of hiatus hernia, carried on at the Massachusetts General Hospital and covering a period of ten years, has brought out two important points, both of which merit greater emphasis than they have received in the past. One is that hemorrhage may be a symptom of hernia; the second, that the incidence of hiatus hernia is considerably higher than has been appreciated.

Richard Bright[1] in 1836 described a case of diaphragmatic hernia with ulceration. This is probably the earliest reported case of the kind. The earliest roentgenological report with a history of bleeding is that of Carman and Fineman[7] in 1924. One of their patients had a chronic anemia, while another vomited blood; a third vomited blood at least three times following an injury which led to a diaphragmatic hernia. The authors, however, did not correlate the blood loss in any of the 3 cases with the herniation.

In an excellent article in which he discusses the etiology of hernia, Åkerlund[1] presents 24 cases of his own and reviews 60 cases from the literature. Öhnell[17] in a second part of this paper points out the fact that 2 or 3 of their cases vomited blood, or had obvious bleeding on instrumental examination. This is the first correlation between hiatus hernia and bleeding which we found.

Bock[4] in a discussion of one of the Cabot case reports in 1929 was the first American to emphasize the presence of gastrointestinal tract hemorrhage with hiatus hernia. He cited 3 cases with occult blood in the stools and a secondary anemia in which the only roentgenological findings were those of hiatus hernia. In the same year Harrington[10] reported 30 cases of hiatus hernia operated upon, 8 of which had a definite history of bleeding from the gastrointestinal tract without any other apparent cause. Seven of these 8 cases were found at operation to have either erosion or ulceration of the mucosa in the herniated portion of the stomach. These 7 cases were found to be somewhat incarcerated.

Mathews and MacFee[14] presented 2 cases of proved ulcer in patients with diaphragmatic hernia, 1 of whom vomited blood late in the course of disease. They point out the fact that hiatus hernia may be the cause of anemia, especially if the stool is positive in the guaiac test. Truesdale[19,20] in 1932 was able to find only 17 cases of proved ulceration in diaphragmatic hernia. Weitzen[21] in the same year presented 2 cases of diaphragmatic hernia

* From the Department of Radiology, Massachusetts General Hospital, Boston. Presented at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

with bleeding, in 1 of which there was an apparent thickening and hypertrophy of the gastric rugae localized to the herniated portion of the stomach.

Bock, Dulin and Brooke[5] in 1933 presented 10 cases of diaphragmatic hernia with secondary anemia. Two came to autopsy. The gastric mucosa in the herniated portion was found to show large submucosal blood vessels with pin-point areas of hemorrhage, while that in the non-herniated portion appeared normal.

Gardner[9] presented 28 cases of diaphragmatic hernia with secondary anemia. Of these, 5 had true peptic ulcer, and in 8 the anemia was considered to be due to hernia. Gardner attributed the bleeding to venous congestion in the herniated portion of the stomach as a result of the muscular compression of the diaphragm. He advised first treatment for the secondary anemia in addition to a medical ulcer regimen, and if this proved unsuccessful, operation later.

Jones,[13] in an excellent paper on the clinical symptoms of hiatus hernia, mentions that in 91 cases of hernia, 4 cm. or less in size but in patients with definite symptoms of hernia, 22 had a history of bleeding. He found 6 cases of bleeding in 37 similar cases with larger herniae.

Morrison[16] and Healy[11] were the first to emphasize the relative frequency of non-traumatic herniae of the stomach through the esophageal hiatus. In 1925 Healy[11] stated that roentgenological study was the best method of diagnosing hiatus hernia. Schatzki[18] stressed the high incidence of hernia, especially in older patients. He found that in a group of 30 patients, sixty-five years of age or older, 14 had demonstrable hiatus herniae. By increasing the intra-abdominal pressure with air insufflation of the colon, he was able to show similar herniae in 8 additional patients. In other words, 73 per cent of a group of 30 elderly patients were found to have demonstrable hiatus herniae.

In order to determine the incidence of hiatus herniae in a group of clinic patients, one of the authors recently examined 100 consecutive patients during a two month period. Each patient was examined in both the upright and the horizontal positions with the esophagus filled with barium, and in both the left and right oblique position. In all cases manual compression of the epigastrium was used. Nine patients, 6 female and 3 male, showed a hernia. The average age of the entire group was 43.5 years while the average age of the 9 patients with hernia was 45.3 years, or slightly above that of the entire group. Most of the 100 patients were examined primarily for peptic ulcer and were in a fairly young age group, and it is our belief that the incidence of hernia would be even higher in an older age group. Even so, an incidence of 9 per cent is higher than that reported in a recent paper by Beilin,[2] and other authors, but it must be remembered that these cases were examined with special emphasis on hiatus hernia while the reports of other authors are taken from their general statistics, that is, they may not have looked especially for hiatus hernia.

Of the 9 patients with hernia in this small series, 3 gave a history of having vomited small amounts of blood, and 1 of the 3 showed roentgen evidence of gastritis on examination.

The incidence of hiatus hernia in a large clinic cannot be determined accurately unless the routine roentgen examination is directed toward this diagnosis; that is, unless each patient is examined in the horizontal position with the esophagus filled with barium. Some roentgenologists, notably Carty,[8] believe that herniae can be demonstrated in the upright position. Carty examines the patient in the upright right anterior oblique position at full inspiration and with pressure on the abdomen. In this position the barium will take an upward course as it enters the stomach, and in some cases only a "flip" of the barium column may be seen. While many herniae may be seen in the upright position we have found that they are better demonstrated in the horizontal position, and also

that many smaller herniae which are missed in the upright position become visible when the horizontal position is used. In the upright position the hernia empties rapidly and is drawn out into a shape similar to the lower end of the esophagus, so that the cardiac sphincter may not be seen and the asymmetrical relationship of the esophagus to the herniated fundus does not occur (Fig. 1 and 2).

Schatzki's proof that increased intra-abdominal pressure makes possible visualization of hernia previously unseen is additional confirmation, we believe, of our contention that the horizontal position is preferable to the upright position, because changes in intra-abdominal pressure occur in shifting from the horizontal to the upright position.

Jenkinson[12] in 28 cases of hernia found only 2 which were suspected of having hernia when examined in the upright position. In 1930, Moore and Kirklin[15] found that in 2 out of 32 selected cases which were called negative on examination in the upright position herniae were demonstrable in the prone position. Åkerlund[1] points out that the lesions are most often recognized with the patient in the prone or supine position, or lying on his right side. He adds that at times it may be necessary to apply manual compression to the epigastrium in order to demonstrate the hernia, and this is also our belief.

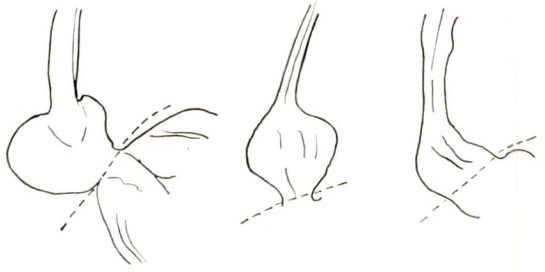


FIG. 1. Posteroanterior and both oblique views. A tracing of the lower esophagus of a patient with a definite history of hiatus hernia, made from spot film taken in the upright position. Note in the right hand view that the hernia cannot be distinguished from dilatation of the lower esophagus.

METHOD OF EXAMINATION AND DIAGNOSIS

At the Massachusetts General Hospital all patients are examined in the prone, the supine and the standing position; and, in our opinion, many hiatus herniae would not be demonstrated if the supine and prone examinations were not made. The Trendelenburg position is also of value.



FIG. 2. Same as Figure 1. Notice in the horizontal position the increase in the size of the hernia. In all three views the hernia can be differentiated from esophageal dilatation.

When a patient is examined in the right anterior oblique position while supine and with the esophagus filled, the narrowing produced by the cardiac sphincter is seen above the herniated fundus. The constriction of the fundus is apparent as it passes through the diaphragm, as is the gastric mucosa. If the patient is turned to the left anterior oblique position the esophagus is seen to enter at the right anterior margin of the herniated fundus. This asymmetry of the relation of the esophagus with the collection of barium above the diaphragm is of considerable importance in establishing the diagnosis. The herniated portion also presents a dumbbell, or inverted molar tooth, shape* which is considered characteristic of hernia (Fig. 4). Care must be taken not to confuse dilatation of the lower end of the esophagus during peristalsis with a hiatus hernia, and if the facts just mentioned are kept in mind no confusion arises. It is not always possible to differentiate between the mucosal folds

* The term "inverted molar tooth shape" was first used by Dr. J. M. Robinson, now in the U. S. Navy.

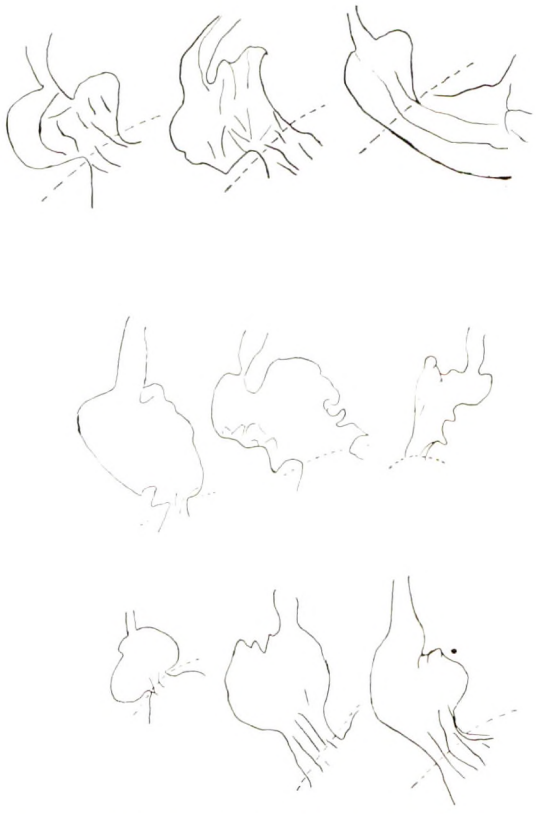


FIG. 3. Posteroanterior and both oblique views. Three different cases of hiatus hernia showing the relationship of the esophagus to the herniated fundus, and the relation of the diaphragm to the stomach.

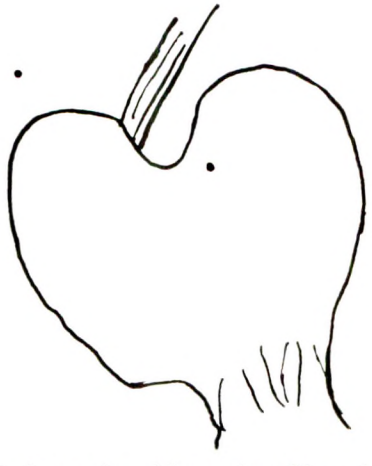


FIG. 4. Left anterior oblique view. Note the asymmetrical relationship of the esophagus to the herniated fundus, the narrowing of the fundus as it passes through the diaphragm. This is a typical inverted molar tooth shape.

of the esophagus and the herniated fundus of the stomach, and at times it is difficult to localize the cardiac sphincter. In a rare case, the actual hernial sac may be seen in the lower mediastinum as a soft tissue mass, fusiform in shape and smooth in outline. The usual differential diagnosis

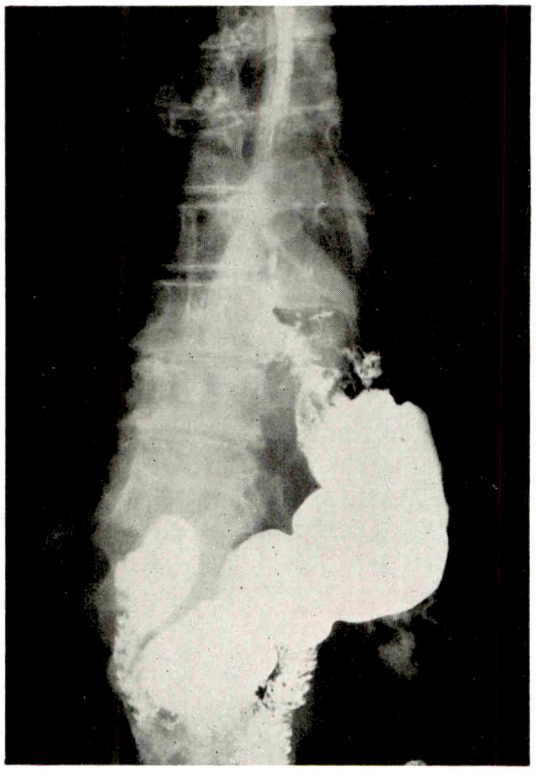


FIG. 5. A patient with a large hiatus hernia and a definite ulcer in the herniated portion of the stomach. Note the large ulcer in the herniated fundus and the soft tissue mass in the lower chest, due to the hernial sac. The presence of a soft tissue mass in this position should suggest the presence of a hiatus hernia.

of such a mass lies between metastatic or primary tumor and abscess; and the fact that hiatus hernia may cause a similar shadow is important. The diagnosis can be confirmed easily by a swallow of barium (Fig. 5).

STATISTICAL DATA

Between 1930 and 1940, 221 cases of hiatus hernia were reported in the Department of Radiology of the Massachusetts

General Hospital. This figure does not represent the total number of patients with hiatus hernia who had studies of the upper gastrointestinal tract, for in many cases the herniae were not recorded because the hernia were found in a period of less than two months. When one further considers that this series was compiled by one of the three regular roentgenoscopists in one division of the hospital it becomes evident that

TABLE I

GROUP I—PATIENTS WITH POSITIVE HISTORY OF UPPER GASTROINTESTINAL TRACT BLEEDING

Case	Age	Sex		Size Hernia	Hemoglobin Per Cent	Erythrocyte Count	Other Findings
		M	F				
K.C.	62		x	⅓ stomach	65	3.68	Hernial opening small, but emptied readily
M.K.	47		x	Small	?	?	None
I.C.	38	x		Small	70	4.1	None
J.O.	43	x		Large	51	3.55	Localized gastritis in herniated portion. No ulceration
E.O.	55		x	Small	?	?	Traction diverticulum of the esophagus
W.M.	65	x		6×4 cm.	90	5.2	Duodenal diverticulum. Sulfapyridine for pneumonia
W.R.	69	x		Small	65	4.5	Healing ulcer in upper body of stomach by gastroscopy
W.D.	69	x		Small	65	2.25	Questionable gastritis while bleeding
A.H.	46		x	6 cm.	75	5.34	Small diverticulum of second portion of duodenum
A.B.	63		x	Entire fundus	70	3.81	Hernia did not reduce
A.M.	68		x	5 cm.	70	3.85	Questionable ulcer in hernia by roentgen examination. Inflammatory stenosis of esophagus by gastroscopy
M.W.	55		x	4 cm.	42	1.23	Redness of mucosa around cardia by gastroscopy
M.P.	71		x	8 cm.	?	?	Diverticula of colon and esophagus. Given sulfapyridine. Ulcer in herniated portion at postmortem
C.M.	53	x		4 cm.	60	2.5	Gastritis in hernia by roentgen examination and gastroscopy
E.G.	71		x	2 in.	70	3.96	None
A.P.	50		x	¼ stomach	55	3.5	Swelling of folds in prepyloric area. Gastritis?
M.H.	50		x	Small	85	3.85	Gastritis on upper greater curvature with bleeding by gastroscopy
A.M.	60	x		Small	80	4.5	Hypertrophic gastritis high on posterior wall by gastroscopy
T.G.	55	x		Large	75	3.4	None
Total	19	8	11				

examiner did not always regard them of sufficient significance in the particular case under question.

As further evidence that these 221 cases are not the exact number seen in a period of ten years is the fact that in 100 patients examined by one of the authors, 9 cases of the total of 221 reported cases in ten years is far too small a figure.

An analysis was made of the 221 cases with special attention given to the incidence of bleeding. This group included patients whose hernia was associated with cancer or ulcer of the stomach; but, where

TABLE II

GROUP 2—PATIENTS WITH POSITIVE HISTORY OF GASTROINTESTINAL TRACT BLEEDING WITHOUT HEMATEMESIS

Case	Age	Sex		Size Hernia	Hemoglobin Per cent	Erythrocyte Count	Other Findings
		M	F				
E.L.	53		x	4 cm.	65	3.77	Gastritis in hernia. Diverticula of colon and duodenum
H.C.	62	x		Small	8 gram	2.92	Sigmoid diverticula
N.C.	82	x		?	60	2.9	Question of polyps on barium enema
J.v.M.	60	x		Large	38	2.9	None
J.F.	64		x	½ stomach	5 gram	3.9	None
H.U.	66		x	Moderate	50	2.96	None
C.B.	50		x	3 cm.	80	4.0	Question of duodenal ulcer
J.L.	74	x		Small	70	3.47	None
C.M.	63	x		½ stomach	58	3.9	Large ulcer in herniated portion of stomach. This decreased in size with treatment
Total	9	5	4				

such obvious cause for bleeding existed, they were excluded from the number whose hemorrhage was considered as due to hernia. On the other hand, cases of hernia with other gastrointestinal tract pathology, such as diverticula, a rather infrequent cause of hemorrhage, are included in the group with bleeding due to hernia. Our material for study can be divided into three broad groups:

1. Patients with a positive history of hematemesis. This group contains only those with relatively high gastrointestinal tract hemorrhage, and is by far the most important (Table I).

2. The remaining patients with gastrointestinal tract hemorrhage, without hematemesis. Included in this group are all those with tarry stools and guaiac positive stools. Bleeding in a certain number of these is probably due to polyp or other pathology which was not diagnosed despite repeated barium enemas (Table II).

3. Patients exhibiting anemia of some severity without a positive history of gastrointestinal tract bleeding and in whom no other cause for amenia except hernia was recognized (Table III).

Nineteen patients fell into Group 1; 11 females and 8 males (Table I). The ages of the patients range between thirty-eight and seventy-one years, with an average age of fifty-seven years. The roentgen report gives the size of the hernia as "small" in 7 pa-

TABLE III

GROUP 3—PATIENTS WITH NO HISTORY OF GASTROINTESTINAL BLEEDING

Case	Age	Sex		Size Hernia	Hemoglobin Per cent	Erythrocyte Count	Other Findings
		M	F				
E.A.	75		x	½ stomach	60	3.62	None
E.M.	67		x	Moderate	65	3.22	Vomiting without blood
I.T.	62		x	Entire fundus	50	2.2	Esophageal diverticulum
S.P.	69		x	⅔ stomach	45	3.5	Did not reduce in upright position
Total	4		4				

tients; as "at least 4 cm. in diameter" in 7, while the actual measurement of the hernia is not noted in 5. It was, however, apparently large in this last 5, the size being from one-quarter of the stomach to the entire fundus.

In 10 of the 19 cases there was evidence of either gastritis or ulceration, as determined by roentgenography, gastroscopy or postmortem examination. It is hard to gather from the gastroscopic report whether the ulceration and gastritis were actually in the herniated portion of the stomach, but where a definite location is given it is always high in the stomach in a position where the hernia would exist. One patient developed pneumonia while in the hospital. She was given sulfapyridine, and subsequently developed hematemesis. Postmortem examination of this patient showed the upper 8 cm. of the stomach to lie in a herniated sac, and an ulcer, measuring 1.5 by 0.5 long by 1 mm. deep, was found on the anterior wall 4 cm. from the cardiac orifice.



FIG. 6. Spot film of Figure 5 showing the ulcer crater.

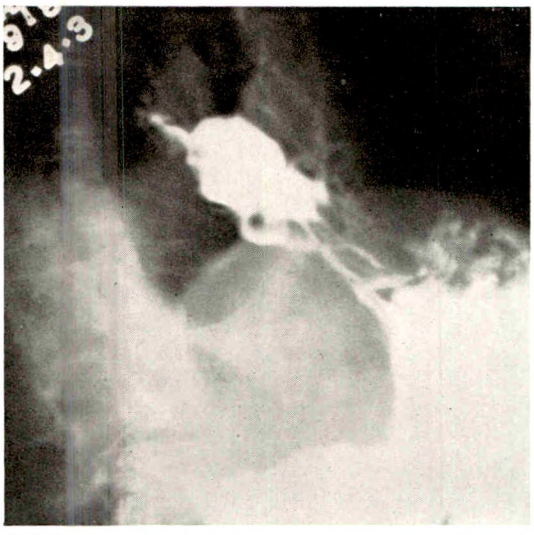


FIG. 7. Patient C. M. (Table 11). Note the large pool of barium above the diaphragm. This represented the actual ulcer crater.

Two of the patients had esophageal diverticula, and in 3 there were duodenal diverticula. One patient showed an inflammatory stenosis of the esophagus by esophagoscopy and a questionable ulcer in the hernia by roentgenography. In 4 patients hernia was the only gastrointestinal tract

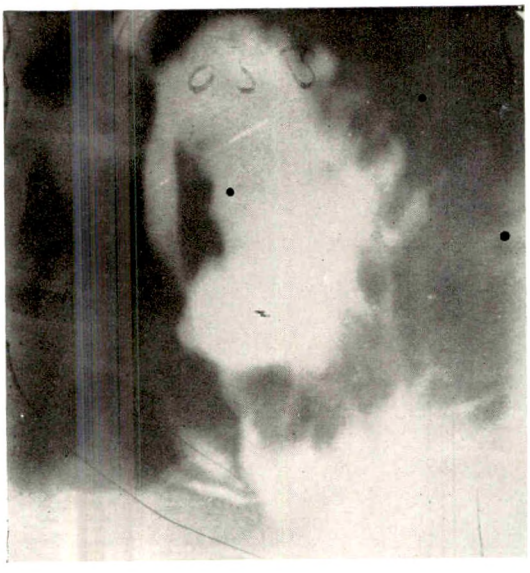


FIG. 8. Spot film of the ulcer crater in Figure 7.

pathology noted. We believe the frequent incidence of gastritis and ulceration high on the stomach wall to be very significant (see Fig. 5, 6, 7 and 8).

In Group 2 (Table II) there are 5 male and 4 female patients, whose ages vary from fifty to eighty-two years, with an average age of sixty-four years. In 2 patients, the size of the hernia was small; in 5, it varied from 3 cm. in diameter to half the size of the stomach; in 1, the size is not noted. Patient E.L. showed a definite gastritis in the herniated portion of the stomach roentgenologically. Patient C. M. had a large ulcer in the herniated portion of the stomach, which responded well to dietary treatment (Fig. 7 and 8). Patient N.C. showed questionable polyp of the colon, and patient C.B. questionable ulcer in the duodenum. Patient H.C. had, in addition to the hernia, diverticula of the sigmoid. Four patients in Group 2 showed hiatus hernia only.

Group 3 (Table III) was made up of 4 females. The hernia in all 4 was fairly large. One patient had a history of vomiting, but the vomitus at no time was seen to contain blood. Patient I. T., who had a very poor dietary history, had a diverticulum of the esophagus. The fourth patient had diverticulitis seven years after the hiatus hernia was found.

DISCUSSION

In a series of 221 cases of hiatus hernia, 32 had either moderately marked anemia or a positive history of gastrointestinal tract bleeding. We believe that the high incidence of gastrointestinal tract bleeding associated with hiatus hernia is evidence that the hernia may produce bleeding. In several cases active bleeding was noted at the gastroscopic examination. We obviously have no proof that all of the 32 cases actually bled in the herniated fundus and we do not mean to convey the impression that the incidence of bleeding from hiatus hernia is 15 per cent, as might be assumed from our data. Bleeding when present (particularly hematemesis) may be due to the hernia, and it may be produced by congestion of the blood vessels in the herniated portion of the stomach with a resultant change in the mucosa, and gastritis or ulceration. This theory is borne out by the fact that 10 of 19 cases with hematemesis showed changes in the upper stomach—changes proved by roentgen, gastroscopic or postmortem examination. We believe also that there is always some mucosal disturbance in cases of hiatus hernia which bleed. Benedict[3] has stated that the cases of hiatus hernia with bleeding which he has observed gastroscopically have shown gastritis and that he considers the bleeding due to the gastritis.

In those cases where there was no positive history of bleeding the anemia may be explained on a dietary basis, or there may have been slight blood loss which was not detected.

SUMMARY AND CONCLUSIONS

1. The diagnosis of hiatus hernia is dependent on two roentgenologic points: one, an asymmetrical relationship between the lower end of the esophagus and the herniated fundus of the stomach; and the other a narrowing of the fundus where it passes through the diaphragm.

2. A soft tissue mass in the lower mediastinum should suggest the possibility of hiatus hernia as well as the usual differential diagnosis of tumor or abscess.

3. The incidence of hiatus hernia is much higher than is generally recognized.

4. Hiatus hernia may be the cause of bleeding.

5. Bleeding caused by hiatus hernia is probably due to constriction of the hernial ring with resultant gastritis and ulceration of the herniated fundus. If neither gastritis nor ulceration is present the lesion will not cause bleeding.

REFERENCES

1. Åkerlund, Å. I. Hernia diaphragmatica hiatus oesophagei vom anatomischen und röntgenologischen Gesichtspunkt. *Acta radiol.*, 1926, *6*, 3–22.

2. BEILIN, D. S. Diaphragmatic hernia of stomach. *Radiology*, 1941, *37*, 68–74.
3. BENEDICT, E. B. Personal communication.
4. BOCK, A. V. Treatment in an obscure case (Case 15022). *New England J. Med.*, 1929, *200*, 88.
5. BOCK, A. V., DULIN, J. W., and BROOKE, P. A. Diaphragmatic hernia and secondary anemia; ten cases. *New England J. Med.*, 1933, *209*, 615–625.
6. BRIGHT, R. Account of a remarkable displacement of the stomach. *Guy's Hosp. Rep.*, 1836, *1*, 598–603.
7. CARMAN, R. D., and FINEMAN, S. Roentgenologic diagnosis of diaphragmatic hernia, with report of seventeen cases. *Radiology*, 1924, *3*, 26–45.
8. CARTY, J. R. An x-ray sign in diagnosis of reducible esophageal orifice hernia. *Radiology*, 1933, *20*, 174–176.
9. GARDNER, K. D. Diaphragmatic hernia associated with secondary anemia. *Am. J. M. Sc.*, 1933, *185*, 561–568.
10. HARRINGTON, S. W. Diaphragmatic hernia associated with traumatic gastric erosion and ulcer. *Collected Papers Mayo Clinic*, 1929, *21*, 790–796.
11. HEALY, T. R. Symptoms observed in fifty-three cases of non-traumatic diaphragmatic hernia. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 266–271.
12. JENKINSON, E. L. Lesions of the diaphragm. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *14*, 16–19.
13. JONES, C. M. Hiatus esophageal hernia, with special reference to a comparison of its symptoms with those of angina pectoris. *New England J. Med.*, 1941, *225*, 963–972.
14. MATHEWS, F. S., and MACFEE, W. F. Gastric ulcers dependent upon diaphragmatic hernia. *Ann. Surg.*, 1931, *94*, 517–523.
15. MOORE, A. B., and KIRKLIN, B. R. Progress in roentgenologic diagnosis of diaphragmatic hernia. *J. Am. M. Ass.*, 1930, *95*, 1966–1969.
16. MORRISON, L. B. Diaphragmatic hernia of fundus of stomach through the esophageal hiatus. *J. Am. M. Ass.*, 1925, *84*, 161–163.
17. ÖHNELL, H. H. Hernia diaphragmatica hiatus oesophagei vom intern klinischen Gesichtpunkt. *Acta radiol.*, 1926, *6*, 23–34.
18. SCHATZKI, R. Die Beweglichkeit von Ösophagus und Magen innerhalb des Zwerschschlitzes beim alten Menschen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1932, *45*, 177–187.
19. TRUESDALE, P. E. Diaphragmatic hernia. *J. Am. M. Ass.*, 1921, *77*, 993.
20. TRUESDALE, P. E. Gastric ulcer associated with diaphragmatic hernia. *New England J. Med.*, 1932, *207*, 385–390.
21. WEITZEN, M. Diaphragmatic hernia with severe anemia. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *28*, 808–812.

BLEEDING ASSOCIATED WITH EXTRAMUCOSAL TUMORS OF THE STOMACH*

By OTTO D. SAHLER, M.D., *and* AUBREY O. HAMPTON, M.D.
BOSTON, MASSACHUSETTS

THE purpose of this paper is to point out the relatively frequent occurrence of gastrointestinal tract bleeding in the presence of intramural submucosal tumors of the stomach, and to emphasize their differential diagnosis.

The term "extramucosal tumors of the stomach" is a very broad, all-encompassing one, including a large variety of histopathologically different tumors. Among the extramucosal tumors of the stomach are leiomyoma, leiomyosarcoma, fibroma, fibrosarcoma, neuroma, neurosarcoma, lymphoma, hemangioma, lymphangioma and aberrant pancreatic tissue. In the present discussion we are primarily interested in the tumors of nerve, muscle and fibrous tissue origin, in both their benign and malignant forms.

REVIEW OF LITERATURE

Campbell[2] in 1915 collected 40 cases of benign tumors of the stomach, most of which proved to show areas of either fibrosarcomatous or myosarcomatous degeneration. He states that fibromata may show a punched-out ulcer. Basch[1] credits Morgagni with having described in 1762 the first myoma of the stomach. In 1919 Holmes[3] described 3 cases of pedunculated tumor of the stomach. Two of these cases were fibrosarcoma and are included in the present report. The third case was a lymphangio-endothelioma, and is not included in the present series. Holmes emphasized the fact that in these cases the peristaltic waves passed over the involved area of the stomach without evidence of break such as is seen in lesions which involve the gastric wall.

Moore,[5] in an excellent paper, discusses in some detail the roentgenological diagnosis of benign tumors of the stomach. He states: (1) Benign tumors produce a filling defect which is circumscribed and punched out in appearance. (2) The filling defect is usually on the gastric wall leaving the curvature regular and pliant. (3) While the rugae are obliterated in the immediate area of the tumor, as in inflammatory and malignant lesions, the rugae surrounding a benign tumor are more nearly normal in their arrangement and distribution. (4) They cause little or no disturbance in peristalsis and retention is uncommon except when the lesion is at or very near the pylorus. (5) They do not reveal a niche, nor is there any incisura or other evidence of spasm. (6) They are rarely sufficiently large to be palpated.

Minnes and Geschickter[4] in a review of the literature were able to collect 341 cases of leiomyoma, 102 cases of neurofibroma, 42 cases of fibroma, 32 cases of lipoma, 1 osteoma, 1 osteochondroma, 3 myomata, and 3 pancreatic arrests in the stomach. In addition, they presented 50 cases of their own.

Odqvist[6] described a case of a gastric neurinoma in which the chief clinical sign was hemorrhage. Roentgen examination of the patient showed the presence of a well circumscribed tumor of a benign type with a stamped out niche. Odqvist believes that the niche formation in gastric neurinoma is generally produced by necrosis and loss of a central area of the tumor into the lumen of the stomach.

Senturia[8] emphasizes that hemorrhage is a common clinical finding in gastric neurinoma. He reports a case with an oval to round, smoothly outlined defect with an "en face niche."

The roentgenological diagnosis of these

* From the Department of Radiology, Massachusetts General Hospital, Boston. Presented at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

extramucosal intramural tumors of the stomach is dependent on the presence of a space-occupying, smooth or lobulated, partially pedunculated, usually sessile mass projecting into the lumen of the the stomach from its wall (Fig. 1). The tumor, if viewed in profile, appears as extrinsic but is freely movable with the stomach. The mucosal pattern of the stomach as a whole is normal. The mucosa adjacent to the tumor is pliable.

The mucosa over the tumor appears smooth and without its normal folds (Fig. 3, *A* and *B*). In contrast to an extrinsic pressure defect the defect produced by the tumor forms a definite abrupt angle with the uninvolved wall of the stomach. This angle is usually obtuse but may be acute. In the rare cases in which the tumor protrudes like a polyp into the gastric lumen an acute angle is seen.[7] If viewed en face the barium shadow at the obtuse margin fades out gradually; that is, the tumor is not sharply defined, but at other points the tumor edge may be quite sharp. The pseudopedunculated appearance of part of the margins is probably due to traction on the gastric wall (Fig. 1). An ulcer may or may not be present, but when present is helpful in making the diagnosis (Fig. 4). Such an ulcer is usually deep and smooth, the depth as a rule being as great as the width (Fig. 5, *A* and *B*). There is, however, no tendency toward spasm or incisura on the opposite gastric wall The ulceration in carcinoma and the pseudo-ulceration in pancreatic arrests are nearly always in the center of the lesion, in contrast to the irregularly placed ulcerations of intramural tumors.

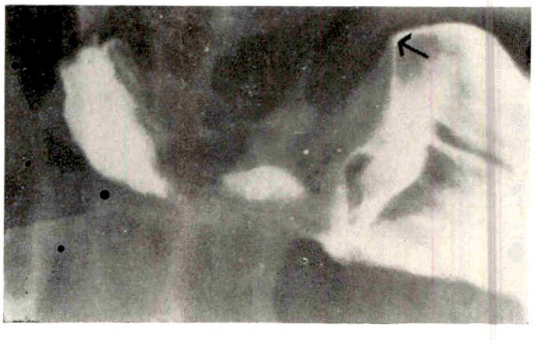


Fig. 1. Note the obtuse angle between stomach and tumor (arrow). There is a smooth defect as if a mass were pressing in from the outside.

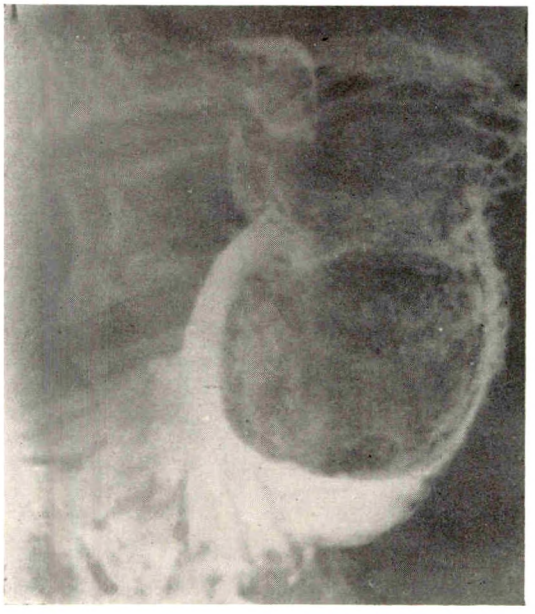


Fig. 2. There is a large space-occupying mass in the stomach. Note that it is coarsely lobulated and that there is relatively normal mucosa above and below the tumor with smooth mucosa in the region of the tumor.

Roentgenologically these tumors must be differentiated from cancer and benign polyps. They can usually be differentiated from cancer by the relative normality of the adjacent mucosa. Other differential guides are the sharpness and the smoothness of outline, and the angle formed at the gastric wall junction. At times, however, it is impossible to differentiate the two types of tumor as was shown in a recent case which roentgenologically was diagnosed as either carcinoma or lymphoma, but which proved to be a necrotic, widely ulcerated fibrosarcoma (Fig. 6, *A* and *B*).

The most common finding which distinguishes these tumors from polyps is that they are usually sessile, whereas polyps are often pedunculated. An additional diagnostic point is the presence of ulceration of the deep type and the relatively smooth

contour of these tumors contrasted with the more lobulated appearance of polyps.

Occasionally a pancreatic arrest in the stomach makes absolute differential dinosis impossible, since these arrests lie in the gastric wall, and the duct opening from the arrest may closely simulate the ulceration of an intramucosal tumor. Pancreatic arrests, however, do not bleed, so the presence of bleeding would favor the diagnosis of other submucosal tumors (Fig. 7).

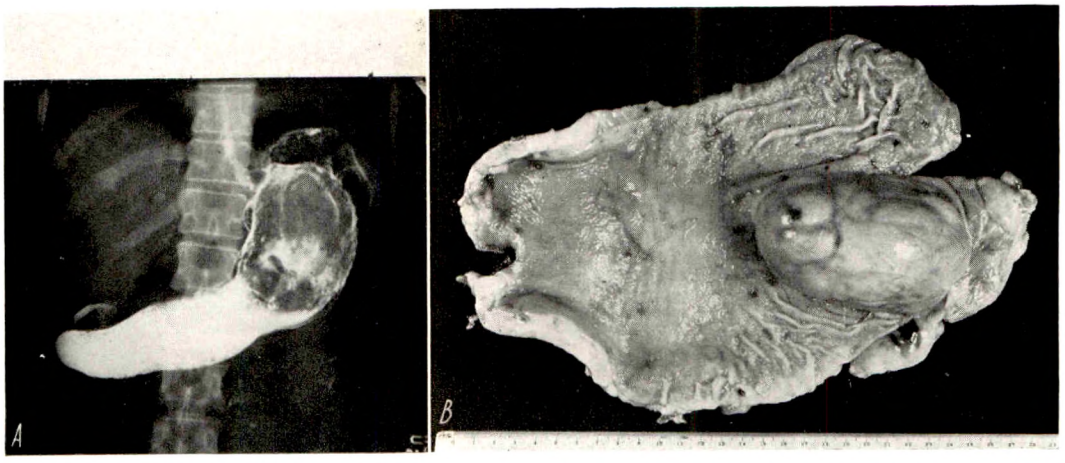


Fig. 3. Case xxii. *A*, leiomyoma. Note the broad attachment at the lesser curvature and the smooth surface of the tumor. *B*, photograph of the tumor. The mucosa over the tumor is smooth. There is hypertrophy of the antrum.

Gastroscopy is of value in diagnosing submucosal tumors, but its value is dependent upon the ability of the gastroscopist. In our own experience the gastroscopist missed the lesion entirely in his first case, while in the last he diagnosed it correctly in the face of a contrary roentgen diagnosis.

The gastroscopic findings are those of a tumor covered by smooth, rather atrophic mucosa, which may show ulceration in one or possibly more areas. The ulceration is, however, relatively small in comparison with the total size of the tumor and the mucosa beyond the actual area of ulceration, but overlying the tumor, shows no evidence of infiltration.

In the past twenty-seven years 24 intramural tumors of the stomach have been removed surgically at the Massachusetts General Hospital.* Twenty-one of the 24 patients have had fairly adequate roentgen examinations.

A review of the available *clinical* data shows the following:

1. Seventeen patients had symptoms of gastric distress, varying from gas and eructation to true abdominal pain similar to ulcer pain, and even including a sensation of "a ball bouncing around in the stomach."

2. Twelve patients gave a positive history of vomiting.

3. Bleeding from the gastrointestinal tract was experienced by 16 patients. (There is one additional case of presumptive bleeding, the patient having been admitted to the hospital because of very severe anemia, the red blood count having dropped from 3,200,000 to 2,000,000 in three weeks. Though no definite statement on hematemesis or tarry stools is made, further confirmative evidence of such bleeding is found in the fact that the tumor showed marked ulceration, and that after operation the anemia, which had failed to respond to vigorous preoperative therapy, cleared promptly.) Of these 16 cases, 7 had a

* A number of these cases have been published in the *New England Journal of Medicine* as "Case Reports from the Massachusetts General Hospital."

history of hematemesis and 10 passed occult blood in the stool. One patient had a guaiac positive gastric analysis.

4. In 3 patients a definite mass was palpable in the epigastrium.

5. Weight loss was noted in 7 patients.

The following reports represent rather typical cases.

CASE REPORTS

Case XXII (Fig. 3, *A* and *B*). R. B., white female, aged fifty-four, was admitted to the hospital on May 21, 1940, with the chief complaint of weakness and gas on the stomach for ten weeks. She had a history of nausea and vomiting for twenty-four years associated with a smothering feeling in the epigastrium. For six months she had noted weakness, vertigo, and tarry stools. Ten weeks before admission she fainted while going to the bathroom. Following this she passed a large black stool which was guaiac positive. Roentgen examination at another hospital was said to show a gastric ulcer on the posterior wall.

On physical examination the patient was obviously anemic. The red count was 4,680,000 and hemoglobin was 55 per cent.

Roentgen examination showed a large oval, smooth, slightly lobulated mass in the body of the stomach, over and around which the barium passed before it entered the antrum of the stomach. The mass measured 12 by 8 by 8 cm. It was slightly movable and was attached to the lesser curvature by a broad base. The pedicle measured at least 5 cm. in width, the upper border being 1 inch inferior to the cardiac orifice.

The gastroscopic report is as follows: In the body of the stomach anterior to the gastroscope and somewhat below it as it lay against the posterior wall there was a rounded, slightly nodular mass covered by smooth, normal appearing mucosa. The entire tumor could not be well visualized, and although the area of the greater curvature was somewhat obscured by retained secretion the impression was that of a non-ulcerated tumor lying below the mucous membrane and presumably attached along the anterior wall and lesser curvature.

At operation the stomach contained a large, freely movable, firm to hard, irregular mass which appeared to measure about 6 by 4 inches. This was in the fundal portion of the stomach close up to the cardia. A total gastrectomy was done.

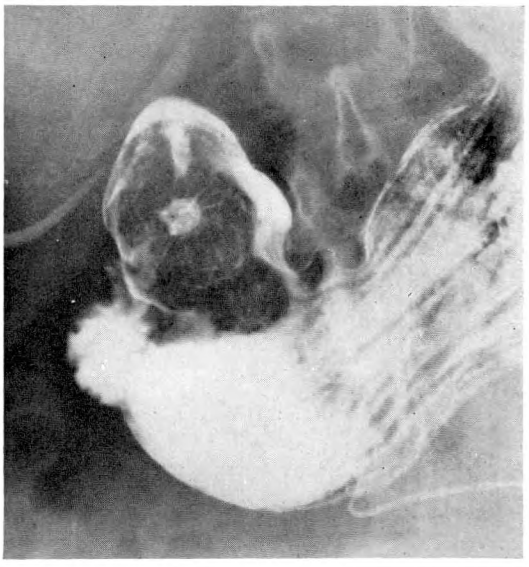


Fig. 4. Note the sharply punched-out ulcer in the tumor and the absence of mucosal infiltration above the tumor. (Courtesy of R. G. Vance, M.D.)

The pathological report is as follows: The specimen is a subtotally resected stomach measuring 12 cm. along the lesser curvature and 25 cm. along the greater curvature. The serosa is salmon-pink, smooth and glistening throughout. The wall of the pylorus is markedly thickened, apparently due to hypertrophy of the muscularis, which measures 1 cm. in thickness. The mucosa is bright pink with a few small dark red areas scattered throughout. The rugae are not prominent. There is no visible ulceration. Originating in the superior resected border and lying in the lumen of the stomach is a large, firm, pedunculated mass, measuring 10 by 7 by 6 cm. The overlying mucosa is not adherent, and the pedicle is small compared to the size of the mass. On section it is firm, and the cut surface presents a grayish-yellow appearance with numerous irregularly scattered dark red, apparently hemorrhagic areas. Histological examination showed the tumor to be a leiomyoma.

Case XXIII (Fig. 5, *A* and *B*). E. F. L., white female, aged fifty, was admitted to the hospital with the chief complaint of a massive hematemesis six weeks before admission. The patient had felt faint upon arising one morning and went to the bathroom, at which time she

vomited about 1 pint of blood. She had no recurrence of hematemesis but felt fatigued.

Roentgen examination showed a mass 7.5 by 7.5 cm. arising from a broad base on the lesser curvature and posterior wall of the fundus of the stomach. The base of the tumor lay just posterior to the cardia. The surface of the mass was rather smooth although there was slight lobulation present. One deep, crater-like depression was seen in the lateral portion of the mass. In changing from the horizontal to the upright position the mass showed only a slight shift in its position within the stomach. The remainder of the stomach presented no pathologic change. The findings were interpreted as those of a tumor in the area described with a deep ulceration. Although several features were a little unusual the roentgenoscopist considered a leiomyoma or a similar tumor as the most probable diagnosis, and carcinoma less likely.

The gastroscopic report was as follows: In the upper part of the body of the stomach in the five o'clock position there was a smooth, rounded submucosal tumor of an elongated shape, appearing to be approximately 5 by 7 cm. in width and elevated above the surrounding mucosa by about 1 to 1.5 cm. There was no visible break in the mucosa overlying this tumor. Near its base the rugae started to pass over the tumor but were gradually flattened out. The mucosa surrounding the lesion was markedly atrophic with blood vessels clearly visible shining through. The findings were those of benign submucosal tumor with atrophy of gastric mucosa. The tumor appeared to extend to within about 1 cm. of the cardia, but did not involve the cardia.

The patient was operated upon and a fundusectomy was done. The pathological report is as follows: The specimen is a segment of stomach measuring 10 by 7 cm. At one edge of the specimen is a round, firm, lobulated, red-pink smooth mass covered by mucosa and measuring 6.5 cm. in diameter. It projects 2.2 cm. above the mucosal surface of the stomach. The center of this mass contains a round, punched-out, gray-pink, irregular ulceration 1.6 cm. in diameter and 0.5 cm. in depth. Just proximal to this ulcer is a small round, punched-out similar depression 4 cm. in width. There is normal appearing gastric mucosa on either side of the mass measuring 4 cm. on one side and 5 cm. on the other. This intramucosal mass extends through the wall as an extrinsic soft, ovoid, lobulated, smooth surfaced, dark-red mass measuring 5.5 by 6.5 by 4.5 cm. On section this contains a cyst filled with old blood, measuring 3 cm. in diameter, surrounded by a soft, necrotic, gray-red rim of tissue measuring up to 1 cm. in thickness. The tumor is slowly growing but has a fair number of mitoses. It is a neurogenic fibrosarcoma.

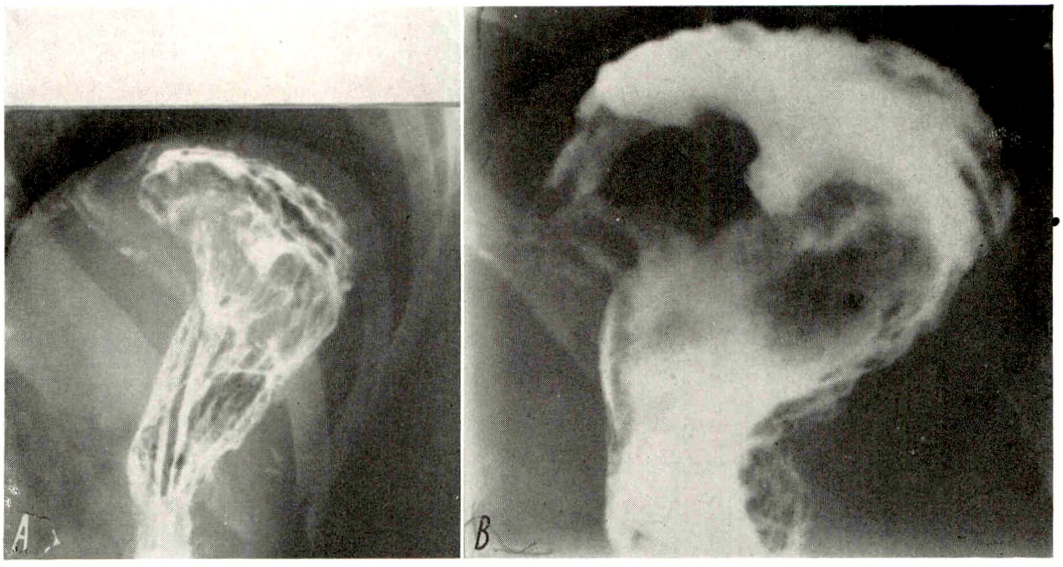


Fig. 5. Case xxiii. *A*, leiomyosarcoma. Note the ulcer which is as deep as it is broad. *B*, spot film of ulcer.

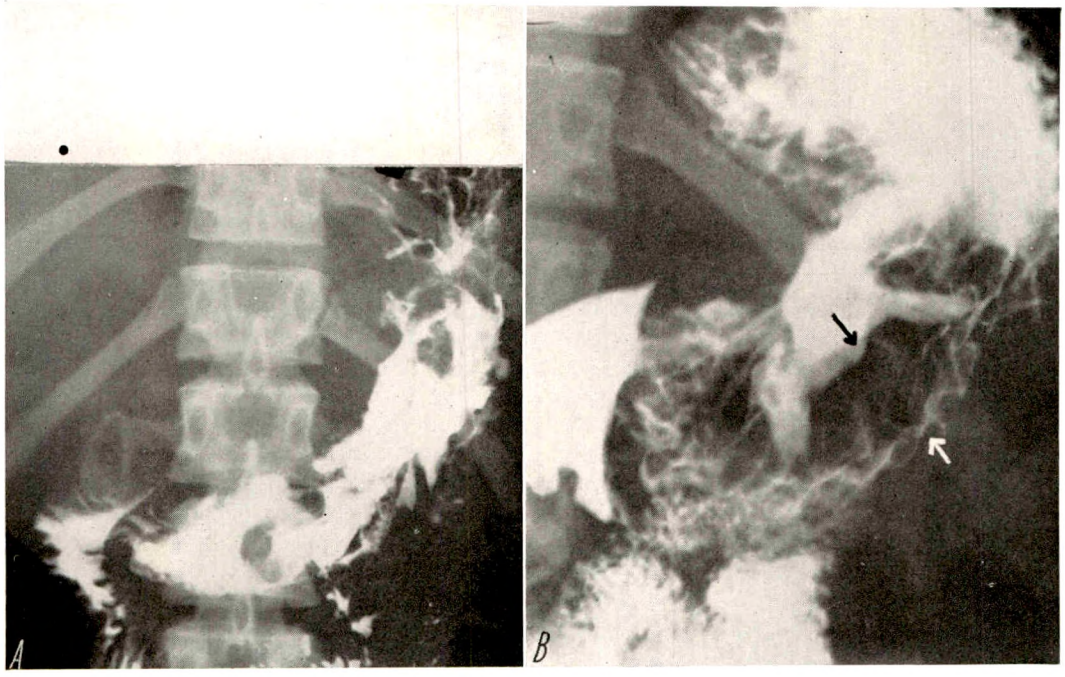


FIG. 6. *A*, a fibrosarcoma with the appearance of a carcinoma. Note the apparent mucosal infiltration and the large irregular ulcer crater. *B*, the margin of the irregular ulceration is unusually broad (arrows). Note the relative absence of normal mucosa and the ragged ulcer crater. This case was roentgenologically classified as a carcinoma. Gastroscopically, the tumor was thought to be extramucosal.

ROENTGEN FINDINGS

In some of the cases the roentgen reports are very brief, while in others fairly full descriptions of the findings are given. Of the 21 cases adequately examined roentgenologically, 20 showed a definite filling defect, which was described as "round" in 7 cases, "smooth" in 9, and "lobulated" in 3. The examiner noted that the outline was "sharp" in 4 instances, and in 9 intraluminal projection was definitely noted. Nine cases showed ulceration. In 1 patient the tumor was not found roentgenologically, despite repeated review of the films pre- and postoperatively. At operation for cholecystitis a small tumor was palpated in the region of the fundus and removed.

Two cases of ectopic pancreas were also seen. Both of thsese showed a definite smooth defect in the stomach, the defect being rounded but in the center there was a smooth dimple. In neither case was there the history of bleeding one would expect, since the dimple did not represent an ulcer crater but the lumen of the duct for the aberrant pancreatic tissue.

An analysis of the position of the lesion showed:

	Cases
Anterior wall	4
Posterior wall	6
Lesser curvature	8
Greater curvature	5
Not stated	1
Upper third stomach	7
Middle third stomach	6
Lower third stomach	11

CLINICAL FINDINGS

Of a total of 24 cases of intramural submucosal tumors of the stomach 16 had a positive history of gastrointestinal tract bleeding and 1 additional case had a presumptive diagnosis of bleeding. One other case in which "questionably tarry stools" is noted, was not included in this group. It becomes apparent that gastrointestinal bleeding is one of the most common symptoms in these cases since it occurred in 66.6 per cent of the patients. The only clin-

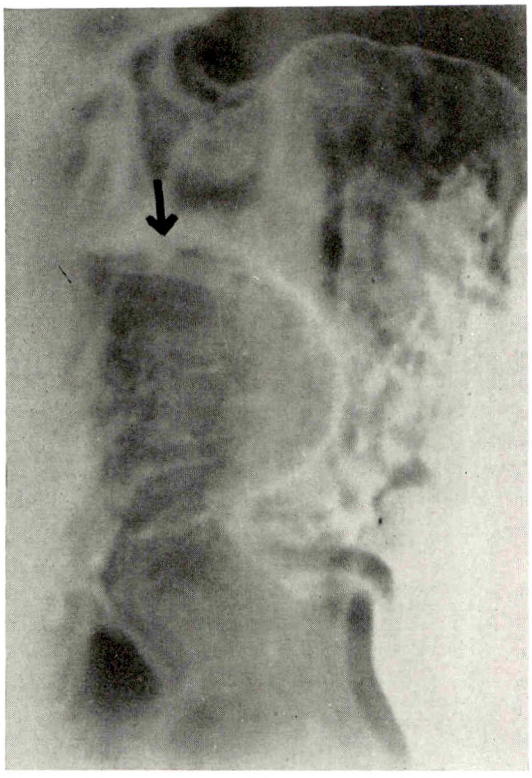


Fig. 7. Aberrant pancreas. Note the intramural defect. Arrow indicates the dimple at the site of the duct.

ical symptom of greater frequency was epigastric distress, but as this distress varied so greatly from patient to patient, from mere "gas" or "belching" to "severe pain" bleeding must be considered the most constant symptom. Bleeding is all the more significant when one considers that in 2 of the cases bleeding was mentioned as the only symptom. Analysis of the type of bleeding shows that in 7 there was definite hematemesis; in 1, the gastric contents was guaiac positive; and in 10, the stools were either markedly tarry or guaiac positive. In several of the patients there was a combination of these signs.

PATHOLOGICAL FINDINGS

Of the 16 cases with a history of bleeding, pathological examination of the surgical specimen showed 9 with definite ulceration in the tumor; 5 with no ulceration; and in 2, ulceration is not mentioned.

Of the 8 cases in which there appeared to have been no bleeding, 1 showed ulceration and 7 showed no ulceration. The pathological diagnoses in the entire group of 24 cases* were:

	Cases
Leiomyoma	8
Leiomyosarcoma	6
Neurofibrosarcoma	4
Neurofibroma	2
Sarcoma	2
Fibrosarcoma	2
Fibroma	1

PROGNOSIS

Of the 24 cases which were operated upon 2 died immediately postoperatively, 1 having had a severe anemia, and the other developing sepsis.

In 3 patients the tumor recurred; 1, a neurofibrosarcoma, with recurrence after six years, died of peritonitis after an operation for recurrence; 1, a sarcoma, recurred after four years; and the third, a fibrosarcoma, recurred after two and a half years.

The follow-up of these patients is not complete, but it is known that 1 patient lived for twenty-five years, 1, for nine years, 1 for seven years, and 6 for at least two years. Five patients have been operated on within the last two years. One patient died of intercurrent disease; 4 cannot be traced.

SUMMARY AND CONCLUSIONS

1. A smooth mass, round or ovoid, usually sessile, in the wall of the stomach should suggest an extramucosal tumor. When viewed in profile, at first glance these tumors may appear to be extrinsic, but in contrast to extrinsic pressure defects the uninvolved wall of the stomach forms an abrupt angle with the tumor defect. This angle may or may not be obtuse, but it is acute only in the rare cases in which the tumor protrudes like a sessile polyp into the stomach. The filling defect moves with the stomach and there is very little alteration in peristalsis.

2. Ulceration, which is relatively deep,

* One case had two different types of tumor.

smooth, and small in comparison with the size of the tumor, is common and should suggest the diagnosis.

3. Bleeding is the most common, constant symptom in extramucosal tumors of the stomach.

REFERENCES

1. Basch, S. Primary benign growths of the stomach. *Surg., Gynec. & Obst.*, 1916, *22*, 165–170.
2. Campbell, A. M. Benign tumors of the stomach. *Surg., Gynec. & Obst.*, 1915, *20*, 66–71.
3. Holmes, G. W. Pedunculated malignant growths of the stomach. Am. J. Roentgenol., 1919, *6*, 279–283.
4. Minnes, J. F., and Geschickter, C. F. Benign tumors of the stomach. *Am. J. Cancer*, 1936, *28*, 136–149.
5. Moore, A. B. Roentgenologic study of benign tumors of the stomach. Am. J. Roentgenol. & Rad. Therapy, 1924, *11*, 61–66.
6. Odqvist, H. Beitrag zum Röntgenbild des Magenneurinoms. *Acta radiol.*, 1937, *18*, 112–118.
7. Schatzki, R., and Hawes, L. E. Roentgenological appearance of extramucosal tumors of the esophagus; analysis of intramural extramucosal lesions of the gastrointestinal tract in general. Am. J. Roentgenol. & Rad. Therapy, 1942, *48*, 1–15.
8. Senturia, H. R. Gastric neurinoma. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 61–65.

SECONDARY LYMPHOSARCOMA OF THE STOMACH

By FRANZ BUSCHKE, M.D., *and* SIMEON T. CANTRIL, M.D.
From the Tumor Institute of the Swedish Hospital
SEATTLE, WASHINGTON

IT IS the purpose of this report to call attention to a certain type of lymphosarcoma of the stomach secondary to a known focus of lymphosarcoma in some distant part of the body outside of the abdominal lymphatic area and characterized by a roentgen appearance suggestive of a solitary malignant lesion of the stomach. This type of lesion is probably more common than is generally recognized.

The most common site of primary localized lymphosarcoma is the lymphoid tissue of the pharynx, stomach, ileum and cecum, and possibly in some lymph nodes themselves. It is a well known fact that secondary deposits from lymphosarcomas of the pharynx in their late stages tend to involve the abdominal lymph nodes. With the clinical picture of a general abdominal distress, the palpatory findings of abdominal masses and the knowledge of a previously treated lymphosarcoma in the pharynx, one may easily overlook the lesion in the stomach itself if roentgen examination of the stomach is not performed as a routine procedure. One may argue that this omission is of little significance since these cases are hopeless anyway. Their occasional importance, however, lies in the possibility of taking such a solitary malignant lesion seen in the roentgenogram for a primary carcinoma or a primary lymphosarcoma of the stomach if the primary lesion has been treated some time ago and the new examiner is not informed as to the previous presence of such a lesion or if the primary lesion has been overlooked. After successful treatment of a lymphosarcoma of the pharynx no trace of tumor or lymph nodes will be found in this original focus of the disease. The assumption of a primary lymphosarcoma of the stomach in such a case would render a slightly more hopeful prognosis since definite cases of primary lymphosarcoma of the stomach cured by irradiation or surgery are on record (Taylor[4]). Furthermore it seems that occasionally even in cases of a secondary lymphosarcoma of the stomach a cure or long intervals of good health may be obtained by radiation therapy. This seems to be a possible interpretation of the case reported by Schindler, which will be reviewed presently. It seems, therefore, that the knowledge of this clinical picture which forms a fairly characteristic entity is not entirely of academic pathologic interest.

Case 1. Our own case observed here recently was that of a white male patient, O. M. S., aged fifty-seven. This patient was admitted on May 29, 1940. Seven weeks prior to that time he noticed the sensation of a foreign body in the roof of the mouth and shortly afterward a lump under the right jaw. Three weeks prior to admission he consulted his local physician who took a biopsy which showed lymphosarcoma. On admission here we found a large necrotic tumor mass occupying the region of the right tonsil with a necrotic ulceration (Fig. 1) The tumor bulged across the midline of the nasopharynx and there was a nodular infiltration of the soft palate with ulceration. Nasopharynx and lateral nasopharyngeal wall were clear. There was a nodularity with ulceration on the posterior surface of the soft palate and a nodular extension of the tumor into the hypopharynx along the posterior pillar down to the level of the epiglottis. There was a lymph node 3 cm. in diameter under the right mandible anterior to the sternocleidomastoid muscle. This node was fairly firm and slightly tender. Anterior to this there was a smaller lymph node; both nodes were movable.

This patient received roentgen therapy from May 29 to July 6, 1940: 6,975 r (measured on the skin) in thirty-nine days with 800 kv. radiation to one right lateral field which included the right lateral nasopharynx, tonsil, hypopharynx and regional lymphatic area.

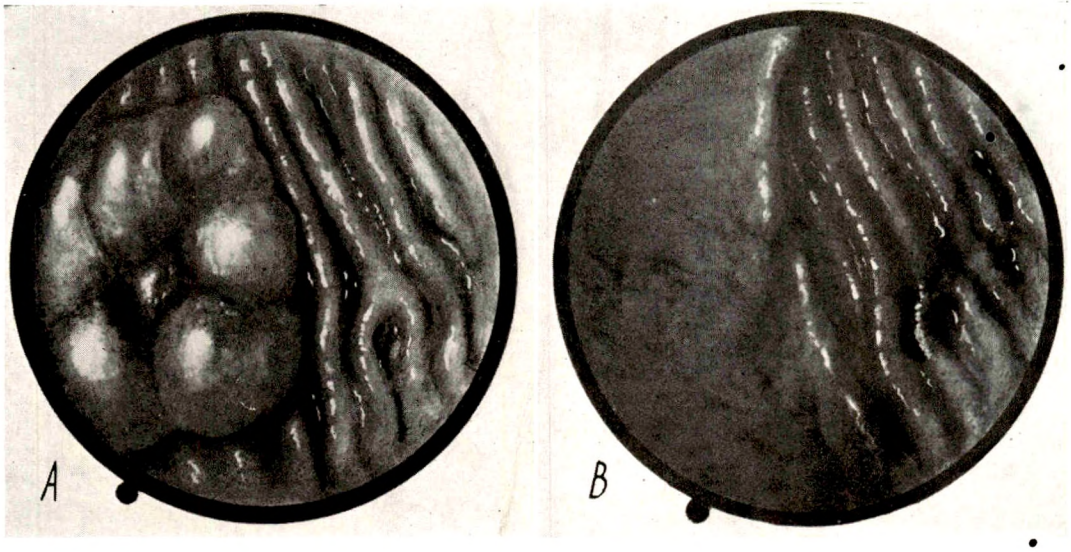


Fig. 3. Case 1. Secondary lymphosarcoma of stomach. Gastroscopic appearance. *A*, before treatment; *B*, after roentgen therapy.

nodules. The entire area was estimated as measuring 4 to 5 cm. in diameter (Fig. 3*A*). The patient then received 2,850 r (measured on the skin) in twenty-seven days with 200 kv. over a left upper abdominal field. Roentgenoscopy on September 16, 1941, five days after the end of this treatment, showed practically a normal stomach (Fig. 2*B*). Gastroscopy toward the end of treatment on September 9, 1941, showed practically normal mucosa (Fig. 3*B*). There was only a slight depression at the former area of ulceration which was covered with a smooth mucosa and was limited by a somewhat raised ridge. This would not be recognizable if one had not known that at this place a lesion had been previously present. This patient returned home in a hopeless condition due to progression of the general spread of the disease.

A strikingly similar case was reported by Kessler.[1]

K. H., male, aged fifty-six. In February, 1932, he noted discomfort in the throat; in May, 1932, he noted a swelling of the left side of the neck. In July, 1932, there was an ulcerated tumor replacing the left tonsil extending into the soft palate and tongue and extending along the lateral pharyngeal wall down to the level of the vallecula. There were walnut sized lymph nodes in the carotid triangle. Histopathologically this was a retothel sarcoma. He received fractionated irradiation between March 11 and 27, 1932, and the primary tumor and lymph nodes disappeared. In October, 1932, the patient complained of a burning sensation along the esophagus and pain behind the sternum. Roentgen examination on March 9, 1933 (Fig. 4) showed an irregular filling defect just below the cardia extending into the smaller curvature in its upper third. In the region of the fundus the tumor was recognizable as a soft part shadow extending into the greater curvature. There was a filling defect the size of a hen's egg in the anterior third of the greater

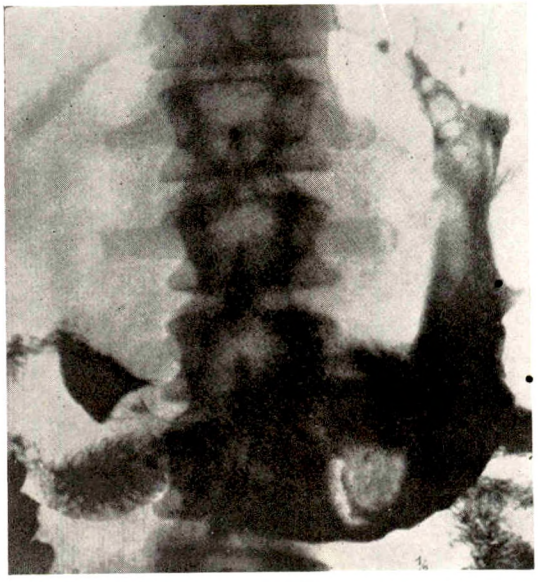


Fig. 4. Secondary lymphosarcoma of stomach; before treatment (from Kessler[1]).

Through the main course of treatment this field measured 12 by 8 cm. to 10 by 8 cm. The tumor responded readily to radiation therapy and had considerably regressed on the seventh treatment day after 775 r. The lymph node had almost disappeared on the ninth day after 1,375 r. Thirteen days after the end of treatment the skin reaction had entirely healed, the patient was gaining weight, and there remained only a scar at the site of previous biopsy on the anterior pillar at the junction with soft palate as the only reminder of the previous lesion. No lymph nodes were palpable.

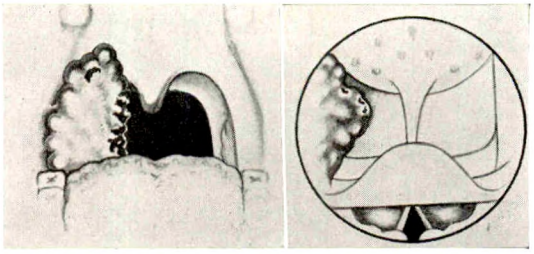


FIG. 1. Case 1. Lymphosarcoma of tonsil. Before treatment.

The following observation, however, showed that this patient did not continue gaining weight as we would anticipate in the case of a sterilized lesion. During the following months we searched repeatedly for metastatic foci in the chest and by clinical examination of palpable areas but did not find any indication of spread of the disease. In August, 1941, about one year after the end of treatment, the patient noticed a swelling of his legs up to the groin. The pharynx at this time appeared perfectly normal and there were no regional lymph nodes palpable. There was a small node 2 cm. in diameter in the left axilla. In the abdomen could be felt two masses of about 5 cm. in diameter each on the right and left side of the umbilicus. His complaints were very undetermined and only of a general abdominal distress. On the basis of the reports in the literature, which we will mention later, we examined the stomach roentgenoscopically and found a large ulceration on the greater curvature (Fig. 2*A*). We interpreted this as secondary lymphosarcoma of the stomach in view of the history of previous lymphosarcoma elsewhere. From the roentgen appearance alone I do not think that any diagnosis beyond that of a malignant ulceration of the stomach could be made or that this lesion could be differentiated from a carcinoma. On August 26, 1941, Dr. Ralph Loe did a gastroscopy and found on the greater curvature at the posterior wall an elevated lesion with a great central ulceration. This lesion was circumscribed and seemed to consist of multiple submucous

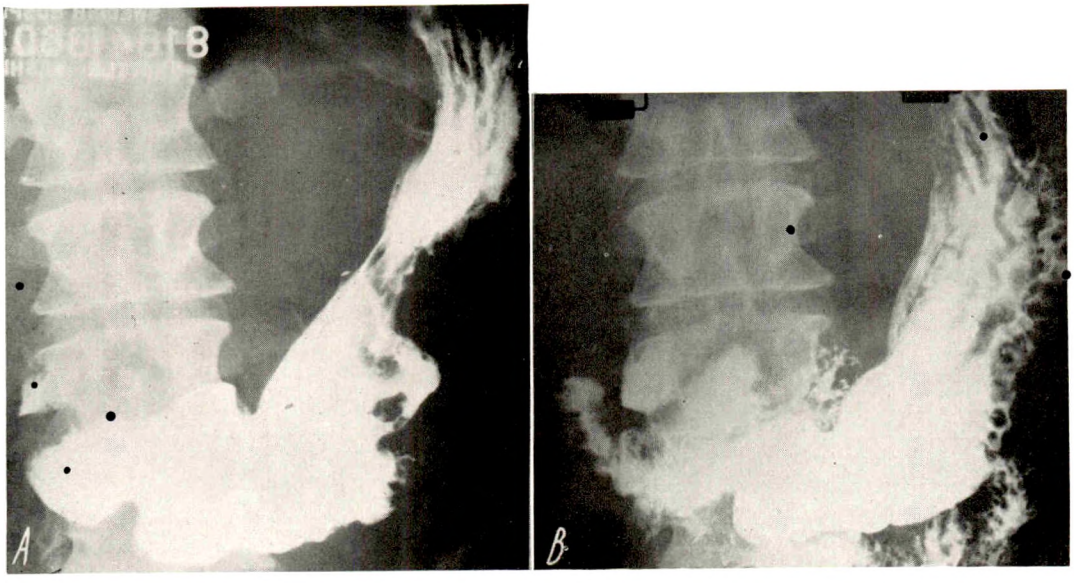


FIG. 2. Case 1. Secondary lymphosarcoma of stomach showing roentgen appearance. *A*, before treatment; *B*, after roentgen therapy.

cm. long and 3 mm. wide. There was a small hemorrhagic spot on the greater curvature of the antrum in a swollen mucous membrane without folds or nodes. In the lesser curvature of the body just above the angulus there were many large nodules. The upper part of the posterior wall was normal (Fig. 6). The patient received five treatments, each of 200 r, through a 20 by 20 anterior abdominal portal, and three treatments likewise, each of 200 r, through a posterior portal. One month later the gastroscopic picture was found to have undergone a spectacular change. The stomach was almost normal, the angulus was smooth and the larger nodes and ulcers had disappeared. The roentgen appearance also was found to be almost normal. Three months later the patient felt better than she had for years. We were informed by Dr. Schindler that *this patient is still in good condition*, September, 1941; this means nine years after the lymph nodes in the neck were removed and *five and a half years after the stomach lesion was treated by roentgen irradiation.*

Our case and that of Kessler show a striking similarity and the sequence of events seems to leave little doubt as to the pathological interpretation of the stomach lesions as secondary foci following the local sterilization of a primary lymphosarcoma of the pharynx. The third case, that of Schindler and Renshaw, is most remarkable because of the long duration of the disease and the freedom of symptoms for more than five years following the treatment with small amounts of radiation to the roentgenologically and gastroscopically demonstrated stomach lesion. Whether in this case the primary focus was also located in one of the tonsils which were removed six months prior to the first observation is a matter of conjecture. We have seen cases of lymphosarcoma of the cervical nodes following a tonsillectomy in which a careful history of the clinical complaints previous to tonsillectomy justified the assumption of an unrecognized primary focus in the removed tonsil. Although the long freedom of symptoms in a primary lymphosarcoma of the tonsil with demonstrated spread beyond the regional lymphatic area is highly unusual it seems that there are cases in which apparently small (and even presumably insufficient roentgen-ray doses) have produced long intervals of good health (Taylor). We are still far from understanding the biology and the gamut of clinical pictures of the disease we call "lymphosarcoma."

REFERENCES

1. Kessler, E. Das Magensarkom. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *50*, 247–263.
2. Renshaw, J. F. Lymphoblastoma of the stomach; report of case, with especial reference to gastroscopic appearance. *J. Am. M. Ass.*, 1936, *107*, 426–428.
3. Schindler, R. Gastroscopy. University of Chicago Press, Chicago, 1937.
4. Taylor, E. S. Primary lymphosarcoma of the stomach. *Ann. Surg.*, 1939, *110*, 200–221.

curvature. Three weeks later the patient was admitted again because of increased difficulty in swallowing. He received irradiation over one anterior and one posterior field, 360 r to each field. There was marked improvement of the subjective complaint. Examination two weeks after this treatment showed only a slight irregularity in the region formerly found to be invaded, and examination after two months showed that the extensive mucosal infiltration in the proximal part of the stomach had completely disappeared. The stomach was then practically normal.

In September, 1933, the patient again had complaints in the abdominal region with normal roentgen findings. One could feel on the right side of the spine at the level of the umbilicus a resistance which was interpreted as a retroperitoneal infiltration. This was irradiated and the patient improved again. In February, 1934, he showed an acute abdominal picture and died within a few days. Autopsy was not done.

A most remarkable case was reported by Schindler[3] and Renshaw.[2]

The patient was a female, aged fifty-one. Tonsillectomy in May, 1932, for salivation. She was first seen in November, 1932, with the complaints of swelling in the neck, which had been present for two years with little change in size, loss of 20 pounds of weight in one and a half years in spite of fairly good appetite and shortness of breath. There was a firm swelling



Fig. 5. Secondary lymphosarcoma of stomach. Roentgen appearance before treatment (from Schindler[3]). (Reproduced with permission of the author.)



Fig. 6. Secondary lymphosarcoma of stomach. Gastroscopic appearance before treatment (from Schindler[3]). (Reproduced with permission of the author.)

about 4.5 cm. in diameter below the midportion of left mandible. A group of firm, discrete cervical nodes was easily excised with the submaxillary gland in toto. These showed microscopically a lymphoblastoma with disappearance of the lymph node structure.* No mediastinal lymph nodes were found on roentgen examination but the patient received a daily dose of 393 r through a 15 by 15 cm. portal over the chest on three successive days. Following this she felt well and gained weight.

In August, 1934, she again complained of shortness of breath. Roentgenogram of the chest showed a questionable evidence of lymphadenopathy and additional roentgen therapy was given through a 20 by 20 anterior chest portal with a daily dose of 306 r for three days, followed two months later by a daily dose of 314 r for three days through a posterior portal. Shortness of breath disappeared and she remained well for sixteen months.

In January, 1936, she reappeared with the complaints of an epigastric pain of one month's duration. At that time the roentgen examination of the stomach revealed enlarged gastric rugae not obliterated by pressure (Fig. 5). The conclusion was reached that there was a submucous infiltration which had not broken through the mucosa. On gastroscopic examination the angulus was found to be the site of marked changes. It was a scalloped nodular curve with a white ulceration toward the posterior wall. The musculus sphincter antri was cord-like and nodular. It contained a greenish-gray linear ulceration about 2

* Dr. Schindler kindly sent us a slide for review which we would diagnose as a small cell lymphosarcoma.

VOL. 49, NO. 4

A PRENATAL DIAGNOSIS OF OSTEOPETROSIS*

By E. L. JENKINSON, M.D., W. H. PFISTERER, M.D.,
K. K. LATTEIER, M.D., *and* MARY MARTIN, M.D.
St. Luke's Hospital
CHICAGO, ILLINOIS

THE intrauterine diagnosis of osteopetrosis by means of roentgenograms is uncommon. One of 141 cases of osteopetrosis in the medical literature had a roentgenological diagnosis in utero.[7] Subsequent study of this patient at the age of six years revealed little evidence of osteopetrosis.[8] Necropsies and roentgen examinations have demonstrated extensive osteopetrosis in the neonatal period.[3,4,5,10]

CASE REPORT

The case presented occurred in a colored female, aged twenty-nine, para I, gravida II, and pregnant six months. Fainting spells, nausea, vomiting, and albuminuria began in the first trimester. Repeated blood Wassermann examinations were negative. An unusual increase in weight and abdominal distention were found at the fifth month antepartum examination. There was progressive abdominal enlargement in the next month despite a salt free diet and restricted fluids. Loss of fetal heart tones and palpable fluid wave suggested polyhydramnios with a multiple pregnancy or monstrosity.

Roentgen Examination. On April 6, 1942, the mother was brought to the Roentgen Department for examination. She was very large and multiple pregnancy was seriously considered. Roentgenograms were made in the anteroposterior and right lateral positions. The films revealed a single small fetus and an exceedingly large uterus, undoubtedly due to polyhydramnios. The placenta was located on the posterior uterine wall. The mother's bones appeared normal and the pelvic inlet was within normal limits. Considering the size of the fetus, there was ample room for delivery.

The films revealed the fetal head to be located in the right upper quadrant, well anteriorly. The breach was located in the pelvis. Practically all the bones of the fetal skeleton were unusually dense and wide. The narrowing of the medullary canal of the long bones could be definitely seen in the prenatal films. The thick cortex encroached upon the medullary cavity. The bones of the extremities and the ribs were about twice the normal width and were marble like in appearance. The outlines of these bones were regular and quite sharply defined. No periosseous thickening or swelling could be seen. The metacarpals, metatarsals, and phalanges of the hands and feet could be easily demonstrated and were sclerotic. The carpal and tarsal bones could not be identified. The entire spinal column showed increased density with practically complete development of the bodies and processes. The ilia and ischia could be easily outlined in the lateral view and were of increased density. We were unable to outline any of the epiphyses of the long bones in the prenatal films. The skull presented many areas of increased density. The bones of the base of the skull which are laid down in cartilage and the bones of the face which are membranous in origin were similarly involved. The supraorbital ridges (frontal bones) were unusually dense. Examination of the bones with a magnifying glass revealed marked increase in density, but the bones were not entirely homogeneous. They seemed to be slightly on the granular side. An interesting finding was the calcification seen in the upper half of the fetal abdomen which we thought due to calcification in the kidneys. Later roentgenograms of the fetus after delivery and postmortem confirmed our belief. *Prenatal Diagnosis:* Osteopetrosis; congenital lues should be ruled out.

One week following the roentgen examination, the pregnancy was terminated and a macerated fetus was delivered. Photographs and roentgenograms of the fetus were made immediately following delivery. The fetus was 36 cm. long, 11.5 cm. anteroposterior diameter, and 12.5 cm. lateral diameter.

The roentgenograms made of the fetus following delivery showed marked swelling of the soft tissues of the skull and an unusually large abdomen.

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15-18, 1942.



FIG. 1. Photomicrograph of decalcified humerus showing calcification of the osteoid tissue and reduced marrow spaces.

The parietal bones were slightly increased in density and were of rather peculiar construction. Perpendicular striae of bone extended outward from the primary center. The striae were well separated as they neared the peripheral sutures and were very sharp. The posterior parts of the frontals and the entire occipital bone showed this same pattern extending outward from the primary center. The bones of the base of the skull were very dense and quite homogeneous. The sella was poorly defined and flat. The facial bones were dense and broad and slightly mottled.

There was no evidence of the epiphyses of the upper or lower extremities. The carpal bones of the wrists were not present and only the center for the calcaneus was present in the feet. The general roentgen findings are similar throughout the entire skeleton: namely, increased density, widening of the cortex, narrowing of the marrow cavity, While the bones are definitely thickened, there is not a complete homogeneity. The trabeculae are not present, but there are small areas of mottling due to less dense bone. The cortical portion of the bones is not smooth. Irregular areas are present, especially in the extremities. The ribs are straight, predominantly dense, but do show some mottling. The metaphyses of the ends of the long bones are smooth and straight. No periosteal reaction is discernible. Calcification is present in the upper abdomen which we believe to be in the kidneys. The chief roentgenological characteristics are as follows:

1. Increased density of practically all of the bones. The increased density is generalized.
2. Widening of all the long bones, especially the tibiae and ulnae.
3. Fine mottling of the long bones.
4. Narrowed medullary cavity.
5. Thickening of the cortex.
6. No periosteal thickening.
7. The base of the skull is exceedingly dense. The sella is flat.
8. Increased striae in the parietal, frontal and occipital bones.
9. Calcification of the kidneys.
10. No periosseous thickening.

The bones of the mother and a half-sister of the fetus were normal in the roentgen examination.

Pathological Findings. The pathological findings in this case are discussed under three headings: (1) The fetus as presented after delivery; (2) the bleached bones of the skeleton after digestion of the soft tissues, and (3) the histological preparations of decalcified bone not previously included in the digestion. The description follows:

The tissues of the body of the female fetus, estimated at six months intrauterine age, were

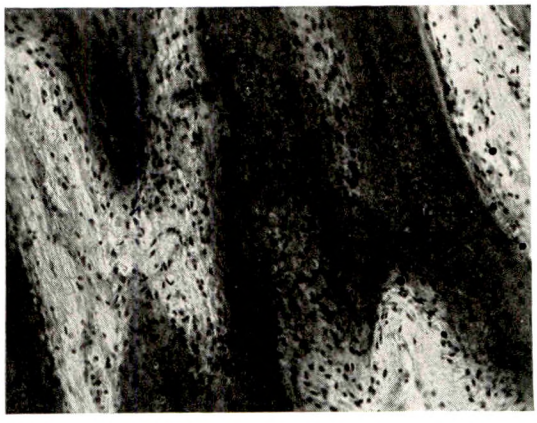


FIG. 2. Photomicrograph of decalcified femur showing heavy trabeculae and fibrous tissue in the marrow spaces.

markedly macerated and hemorrhagic. Deposits of calcium seemed to outline the pyramids of the kidneys. Other viscera had autolytic changes. The long bones of the extremities, the ribs, the vertebrae, the bones of the cranium, and the bones of the face were greatly thickened and calcified.

The soft parts were digested with a 1 per cent NaOH solution, the bones recovered and bleached. They were chalky and fragile, but heavy and much larger than usual. The bones of the calvarium consisted of rather soft bone with no myeloid. In the large flat bones delicate spicules radiated from a thick spongy central portion. The occipital bone had a thick heavy central portion. The lateral portions were radiating spicules. The frontal bone was particularly heavy. The supraorbital ridge was thick and the supraorbital foramen had a diameter of 1 mm. The supraorbital plate had a thickness of 3 mm. The bone forming the floor of the anterior fossa was thick and porous. The pyramid of the temporal bone was heavy, dense, and the canals and foramina were prominent. The pyramid portion was 1.5 by 1.2 cm. The squama were thick and heavy. The zygomatic processes were 1 cm. in length and 0.4 by 0.4 cm. in their other dimensions. The short styloid processes were ossified. The thick greater wings

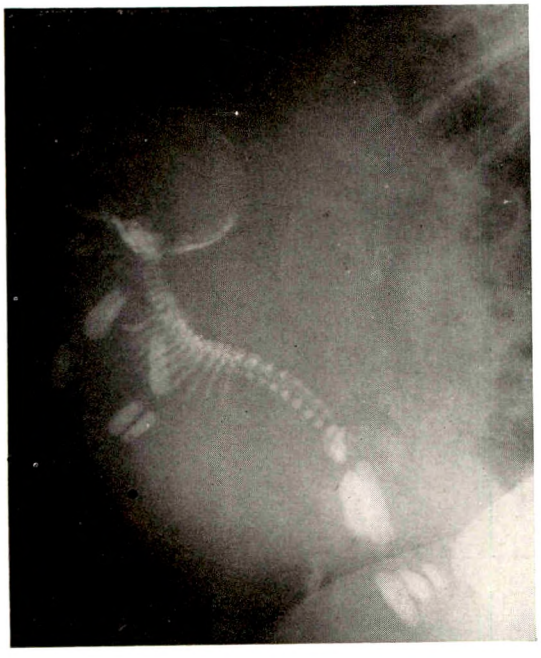


Fig. 3. Lateral view showing fetus in utero; dense, widened, and thickened bones.



Fig. 4. Photograph of the macerated fetus.

and leaf-shaped lesser wings were well formed. The dorsum sellae were small but ossified. The nasal bones were well developed thin plates of chalky bone. The ossicles were about three-fourths of adult size and were well developed. The glenoid processes of the scapulae were completely ossified and were each about three-fourths the size of the remainder of the scapula. The hyoid bone was not identified. The coracoid processes were heavy but short. The mandibles were thick and heavy. The clavicles were 2.5 by 0.5 by 0.5 cm. There was a large heavy manubrial plate and two slightly smaller masses believed to be bones of the body of the sternum.

The large long bones were thick and heavy. The enlargement was diffuse. The fibula and ulna were much thicker in proportion to the radius and tibia than the normal relationship. The humerus was 2.5 cm. long. The central portion had a diameter of 1.2 cm. and the base

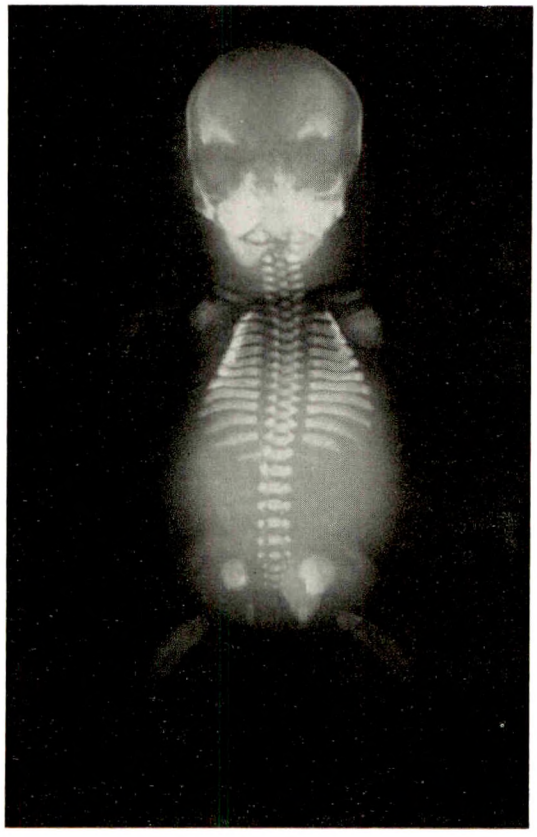


Fig. 5. Roentgenogram of the fetus, showing the increased density of the bones of the upper and lower extremities, ribs, spine, face.

roughly tapered to a diameter of 0.8 cm. at the lower end and 0.9 cm. at the upper end. At the diaphysis were transverse lines. The epiphyseal edge was rough and irregular and the bone here crushed easily. The radius was 2.5 cm., centrally it had a diameter of 0.8 cm. The shaft was diffusely enlarged. The diameter was approximately 0.7 cm. and the distal end was 0.5 cm. Five millimeters from the end of the bone was a transverse ridge and at the upper end were similar less distinct transverse lines parallel to the epiphyseal line. The ulna was slightly smaller and diffusely enlarged. It had a diameter near the center of 0.7 cm. The proximal end was 0.4 cm. in diameter and distally 0.4 cm. in diameter. No carpal bones were identified, but many irregular fragments remained and some of these probably represented carpal bones. The metacarpals were thick and much less chalky than the other bones. The largest was 1 cm. It was narrow near the center and flared at each end. Four phalanges were identified, grossly similar to the metacarpals. The cortex was much firmer than that of the other bones. The femur was 3.7 cm. long and diffusely enlarged. Near the center the shaft had a diameter of 1.3 cm. There were longitudinal lines at each end where the bones had a ruffled appearance and there were at each end faint transverse lines parallel to the epiphyseal line. The epiphyseal surface was rough and irregular. Proximally the diameter was 1 cm. and distally it was 1.2 by 0.8 cm. The tibia was grossly similar. It was 3.5 cm. long. The greatest diammeter at the upper third was 1.2 cm. At the proximal end the bone was 1 by 0.8 cm. and the epiphyseal surface was rough and irregular. Distally it was 0.7 cm. The fibula was 2.7 cm.

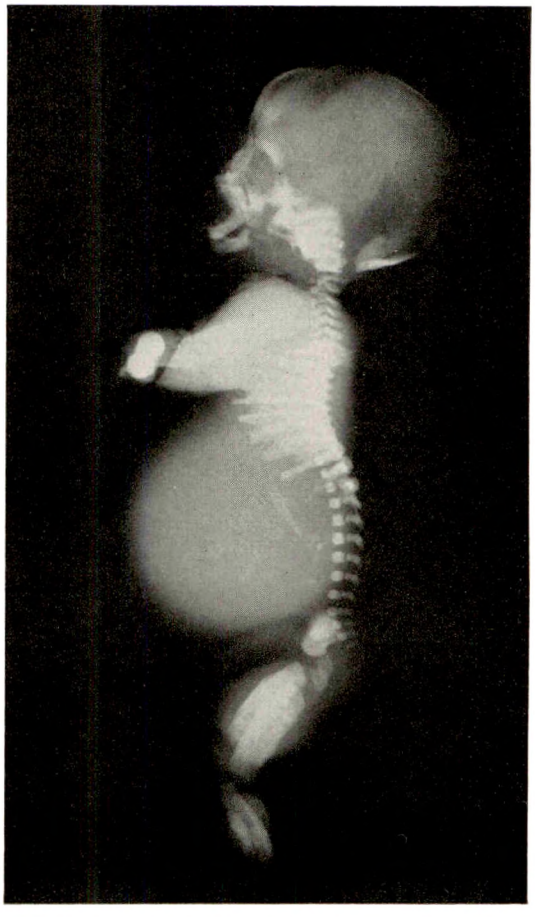


Fig. 6. Roentgenogram of the fetus, lateral view, showing calcification in the kidneys, increased density, and widening of the bones of the upper and lower extremities, vertebrae, ribs, and base of the skull, and a large pendulous abdomen.

long and diffusely thickened. The markings were similar to the other bones. At the proximal end the diameter was 0.4 cm. and distally it was 0.4 cm. Centrally it was 0.8 cm. in diameter. The ribs were heavy spongy bones with greatly reduced marrow cavities. The largest, along its convex edge, was 3.5 cm. The first ribs were well developed. The bodies of the vertebrae were heavy solid masses. The largest recovered were 0.8 by 0.5 by 0.5 cm. The lamina of all the vertebrae were thick. The spinous processes were well developed and the thoracic ribs had well developed thoracic processes. The wings of the pelvic bone were large and heavy. The margins were ruffled. The ischia were heavy. The ischial tuberosity was well developed. The foramen had a diameter of 1 mm.

Histopathological Findings. Bone "A": Longitudinal sections of the decalcified femur had at the diaphysis a zone of unmodified hyaline cartilage penetrated by a few blood vessels. There was a variable amount of lime in the cartilage matrix here. Beneath this was a narrow zone of calcified cartilage where the large swollen vesicular cells in rows were separated by narrow walls of more basophilic matrix. The region beneath had cartilage erosion and endochondral ossification. This was irregular in extent. Narrow spicules of calcified cartilage were surrounded by wide zones of osteoid tissue. Deeper, where the marrow cavity should be present, were wide trabeculae of osteoid tissue, some with masses of persisting calcified cartilage in their centers. Near the center of the shaft was marked irregular ossification of this osteoid tissue. The trabeculae here were wide, markedly irregular and compressed the marrow. There was little difference between the compacta and spongiosa except in the nature of the elements found in the reduced marrow spaces. Periosteal bone formation was active but there was here an abnormal amount of osteoid tissue with irregular lime deposition. In the narrow marrow spaces between the thick peripheral trabeculae was a cellular fibrous tissue. Here were many persisting masses of unchanged hyaline cartilage. There was no fat in the small marrow spaces. Centrally the relatively small amount of hematopoietic tissue was compressed by masses of cartilage matrix undergoing resolution and lysis. The usual discontinuous layers of osteoblasts were along the margins of the trabeculae but only a few osteoclasts were present. The small amount of hematopoietic tissue contained mainly young cells of the erythrocytic series, many adult macrocytes and large nucleated red cells. There were some young cells of the granulocytic series, very few of them acidophilic. No megakaryocytes were found.

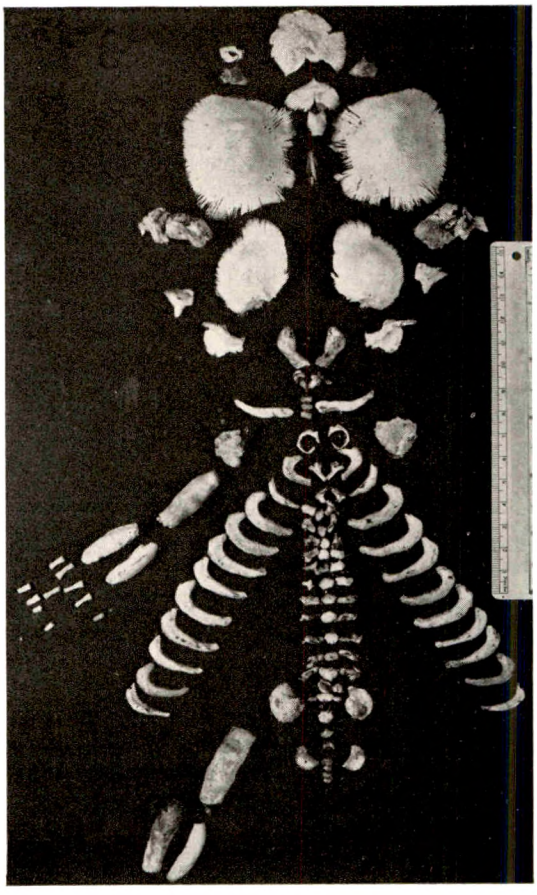


Fig. 7. Photograph of the disarticulated skeleton after removal of the soft tissues.

Section "B": The radius and ulna resembled those described in the femur. Here, however, the persistence of calcified cartilage in the trabeculae was more marked. The wide dense trabeculae had narrow margins of intensely staining osteoid tissue. The marrow spaces contained in a fibrous stroma a moderate amount of hematopoietic tissue.

Section "C": The humerus had essentially the same changes. The dense trabeculae of the spongiosa had more marked ossification and the osteoid tissue was less in amount. The marrow here was mainly loose vascular fibrous tissue. The kidney tissues were markedly autolyzed. However, outlining the calyces and in the walls

of the larger blood vessels near the pelvis were large irregular deposits of calcium.

Diagnosis. Macerated premature fetus; osteosclerosis fragilis generalisata (Albers-Schönberg's disease); calcification of renal tissues; postmortem autolysis of the tissues.

No spirochetes were found in sections of the liver stained by the Levaditi method.

To summarize the outstanding changes in the bone tissues of this case: Grossly, the long bones were diffusely thickened and heavy. Near the diaphyseo-epiphyseal lines were transverse ridges. Particularly well marked at the ends of the tibia were longitudinal striations giving a "ruffled" appearance to the bone. The ulna and fibula were much thicker in proportion to the radius and tibia than the normal relationship. The membrane bones of the face and cranium were less involved than the cartilaginous bones. The large flat bones were practically normal. The marked development of the supraorbital ridge, large size of the pyramids and ossification of the styloid processes were noteworthy. The bone tissue was chalky and fragile. Histopathologically the disturbance seemed to be in the ratio between bone formation and absorption. The periosteum was intact. There was endosteal increase in density and thickness. The epiphyseo-diaphyseal lines of the long bones were ragged but epiphyseal development was normal. The sclerosis seemed to have occurred after the centers developed. There was increase of cortical bone with widening and broadening of the trabeculae. The spongiosa was obliterated and the marrow spaces were reduced. Much of the marrow contained fibrous tissue. There was an abnormal amount of osteoid tissue in the centers of the shafts. The significance of calcium material outlining the renal pelvis was difficult to determine. The soft tissues were badly macerated and the finer structure altered by autolysis. No parathyroid tissues were identified.

DISCUSSION

Roentgenological features of osteopetrosis were first described in 1904 by Albers-Schönberg,[1] who called the condition "marble bones." The term "osteopetrosis" was suggested by Karshner[5] on the basis of bone petrifaction. Pirie[8] demonstrated that the density and drilling qualities of the involved bones resembled chalk rather than marble and called them "chalky bones." The etiology of osteopetrosis is not known. The rôle of chronic infection, avitaminosis, and anomalies of osteogenesis are not well defined. Péhu, Policard and Dufourt[6] suggested a parathyroid tumor in their case as the etiological factor. Pugsley and Selye[9] injected parathyroid hormone in rats and observed an initial increased calcium excretion subsequently followed by a normal or subnormal excretion. This acquired resistance to experimental hyperparathyroidism could be converted into a condition closely resembling marble bones if the administration of parathyroid were continued. The osteoclastic reaction (osteitis fibrosa) changed over to an osteoblastic one (marble bone formation) at the same time that the increased calcium excretion and hypercalcemia returned to normal limits.

Péhu, Policard and Dufourt,[6] Schulze,[11] and Alexander[2] found deposits of calcium in tendons, myocardium, blood vessels, skin, and in the kidneys, and believed that parathyroid hyperactivity was significant. Parental consanguinity and familial tendencies have frequently been reported. Sex and race are not important. Most reported cases have been diagnosed before puberty. Pirie[7] believes that the disease starts at the epiphyseal line where alternating transverse bands of greater and lesser densities are so common that they are considered pathognomonic. Similar findings, however, may be found in chronic illness due to nutritional growth arrests. The pathogenesis of the poorly differentiated, unorganized amorphous bone is not decided. The marrow cavity is replaced by spongiosa having a marked increase in number and thickness of individual trabeculae, between masses of persisting calcified cartilage. The lamellae of the cortex are increased in number and are more compact. The pathogenesis may result from abnormalities in the hyaline matrix, the osteolytic mechanism, or failure of metaplasia from fibrous to osteoid tissue. Various authors disagree as to the rôle of osteoblasts and osteoclasts. In the case presented the usual discontinuous layers of osteoblasts were along the margins of the

trabeculae but only few osteoclasts were present. Osteopetrosis may be suspected clinically by its secondary manifestation. The diagnosis is usually made by roentgen studies.

All the bones of the skeletal system are affected. The vertebrae, pelvic bones, base of the skull, and ends of the long bones are most extensively involved. The hard cortical bone is more than twice the usual thickness and there is condensation and broadening of the bony trabeculae. The spongiosa and marrow elements may be obliterated by the encroaching compacta and replaced by fibrous tissue. The hyperplastic bone growth is entirely endosteal. The periosteum is rarely involved.

The ossification centers appear at the normal time and epiphyseal unions are only slightly delayed.

The chemical analyses of the bones have failed to reveal any characteristic changes in their calcium, phosphorus, magnesium, or carbonate content. The calcium and phosphorus content of the blood serum is normal. The osteosclerotic or myelophthisic anemia accompanying the disease probably results from encroachment on the marrow elements by the compacta. Metaplasia of extramedullary hematopoietic centers may account for the enlargement of the liver, spleen, and the lymph glands.

DIFFERENTIAL DIAGNOSIS

A careful history is most important in the differential diagnosis of osteopetrosis. A complete roentgen examination of the skeleton is also imperative.

Congenital syphilis probably presents the most difficult diagnostic problem. In congenital syphilis there is a marked thickening of the periosteum and sclerosis of the bone, but there are also areas of destruction in the region of the metaphyses. Syphilis rarely attacks the bones of the base of the skull, while osteopetrosis usually involves this portion of the skeleton. Serological studies are very important in the differential diagnosis.

Osseous changes in leukemia are not uncommon and were originally described by Hueck in 1879. However, the changes are predominantly infiltrative and destructive rather than proliferative. When sclerosis does appear, it is not so generalized.

In certain parts of the world, chronic fluorine poisoning presents changes which may be confused with osteopetrosis. Here the history is of great importance. The offspring of persons in any way associated with fluorine may show changes of the sclerotic type. In fluorine poisoning the architecture of the bones remains unchanged and calcium fluoride crystals can be identified histologically in the haversian canals. The adjacent soft tissues show osteophyte formation with calcification of the intervertebral ligaments and periosseous deposits.

Some of the more uncommon conditions such as condensing osteitis of Sicard, eburnizing osteitis of Putti, ivory vertebra, or leontiasis ossea, while they may cause some confusion, are usually localized and do not present the generalized sclerosis seen in osteopetrosis.

Paget's disease may present a difficult problem in older patients. However, the changes in the skull, pelvis, and long bones of the extremities are usually quite characteristic The bones are not homogeneous and the trabeculae instead of being absent are very prominent and thickened

Chronic metallic poisoning such as lead or phosphorus may cause diagnostic difficulties. The history, chemical analysis, and examination of the red blood cells are of great importance from a differential standpoint. When the irritating metals are withdrawn the patient's condition very often improves and the areas of sclerosis disappear. Osteopetrosis presents no peripheral neurological findings.

When multiple fractures occur in a patient, the differential diagnosis between osteopetrosis and osteogenesis imperfecta presents a problem. However, in the latter condition, the density of the bones is decreased rather than increased and trabeculae are present. Healing of the fractures

may take place in either condition. Moreover, marked deformities and bowing of the bones due to softening can be noted in osteogenesis imperfecta.

The course is frequently rapid and fatal. Involvement of the bones and foramina of the base of the skull may cause blindness, hydrocephalus, and hypophyseal dysfunctions. Mineral, vitamin, and endocrine therapy have been unsuccessful.

SUMMARY

1. A case is presented of prenatal osteopetrosis diagnosed roentgenologically and confirmed by necropsy.

2. A complete review of the literature reveals no confirmed prenatal diagnosis of osteopetrosis.

3. The skeletal changes reveal that cartilaginous and membranous bone show similar involvement.

4. From the review of the literature and the evidence presented in our case, osteopetrosis undoubtedly originates in utero and when accompanied by hydramnios, the fetal mortality is high.

5. It is not uncommon for patients with osteopetrosis to reach adult life.

REFERENCES

1. Albers-Schönberg, H. Röntgenbilder einer seltenen Knochenerkrankung. *München. med. Wchnschr.*, 1904, *51*, 365.
2. Alexander, W. G. Report of a case of so-called "marble bones" with a review of the literature. Am. J. Roentgenol. & Rad. Therapy, 1923, *10*, 280–301.
3. Assmann, H. Beiträge zur osteosklerotischen Anämie. *Beitr. z. path. Anat. u. z. allg. Path.*, 1907, *41*, 565–595.
4. Goodall, A. Acute myelocythaemia associated with osteosclerosis and other unusual features occurring in an infant. *Edinb. M. J.*, 1912, *8*, 500–507.
5. Karshner, R. G. Osteopetrosis. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 405–419.
6. Péhu, M., Policard, A., and Dufourt, A. L'ostéopétrose ou maladie des os marmoréens. *Presse méd.*, 1931, *39*, 999–1003.
7. Pirie, A. H. Development of marble bones. Am. J. Roentgenol. & Rad. Therapy, 1930, *24*, 147–153.
8. Pirie, A. H. Marble bones. Am. J. Roentgenol. & Rad. Therapy, 1933, *30*, 618–620.
9. Pugsley, L. I., and Selye, H. Histological changes in bone responsible for action of parathyroid hormone on calcium metabolism of rat. *J. Physiol.*, 1933, *79*, 113–117.
10. Schmidt, M. B. *Verhandl. d. deutsch. path. Gesellsch.*, 1907, *11*, 288.
11. Schulze, F. Das Wesen des Krankheitsbildes der "Marmorknochen (Albers-Schönberg)." *Arch. f. klin. Chir.*, 1921, *118*, 411–438.

Vol. 49, No. 4

GHON'S TUBERCLE

RE-EVALUATION OF A CONCEPT*

By ROBERT G. BLOCH, M.D.

CHICAGO, ILLINOIS

OVER twenty-five years ago Ghon[5] published his studies on primary tuberculous infection. Since that time the small calcified focus in the lung has played a dominant rôle in the clinical aspect and the epidemiology of tuberculosis, and the term, "Ghon's tubercle," has been universally accepted as signifying the calcified single or multiple remnants of a tuberculous lesion resulting from a primary infection acquired in childhood. This interpretation is made regardless of the age of the patient in whom such a lesion is found; its origin is placed back in the early years of life from the adolescent and senile age period alike.

It is the purpose of this paper to re-examine the soundness of that apparently so firmly established concept on the basis of more recent experience. As in other fields of medicine, the increasing importance of pathologic study through serial and large scale roentgenologic observations in the field of tuberculosis compels us to reconsider some aspects of our knowledge regardless of how securely they may seem to have been founded in the past.

Ghon examined tuberculous lesions in 184 children by autopsy in St. Anne's Hospital in Vienna. Of that number he described in detail his findings in 125 as to pathologic detail, number, size, and distribution of the lesions. Table 1 shows the age distribution of his patients. The oldest was fourteen years, the average age four years, with more than one-third of the individuals less than two years of age. Ghon made no attempt to apply his findings to tuberculous remnants found in the lungs of adults; apparently it was the widespread recognition which his work received, rather than his own interpretation of his findings which led to a practice of ascribing all calcified foci in the adult to childhood infection. Without adequate observations which could form an acceptable scientific bridge from childhood to the adult age, the calcified focus discovered at any age and Ghon's tubercle are now synonymous; the term in that meaning has become common in everyday medical practice.

TABLE I

AGE DISTRIBUTION OF LESIONS DESCRIBED BY GHON[5]
(184 autopsies; description of 125 examples)

Age Distribution:	Number	Per Cent
Younger than 2 years	47	37.3
2 to 5 years	43	35.0
6 to 10 years	27	21.4
11 to 14 years	8	6.3
	125	100.0

Youngest child aged 2 months.
Oldest child aged 14 years.
Average age—4 years.

A few authors[3,4,6] from different continents and studying tuberculosis in various races have pointed out that calcifications are found more frequently in old than in young individuals; in fact, that there is a steady rise in the frequency of such findings with increasing age. Ten years ago, in beginning our case-finding programs for tuberculosis,[1] we examined a group of 2,300 white persons composed of college freshmen, graduate students, faculty members and hospital personnel of the University of Chicago. The examinations were made partly by roentgenoscopy and partly by stereoscopic chest roentgenograms. There was the striking discovery that calcified tuberculous remnants were more frequent in the older group of indi-

* From the Frank Billings Medical Clinic, Department of Medicine, University of Chicago.

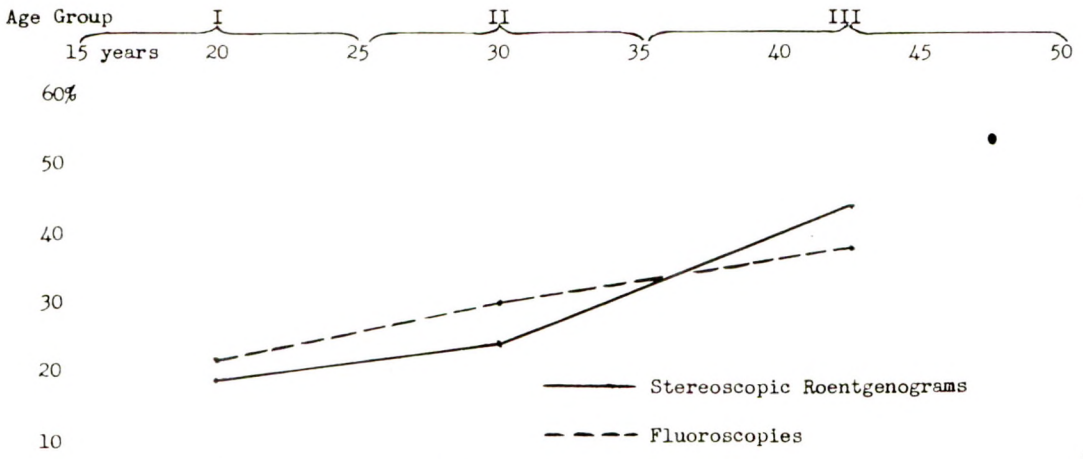


Fig. 1. Percentage of calcifications (Ghon's tubercles) in 2,300 white individuals of various age groups.

viduals. Figure 1 shows the steady rise through the various age groups by roentgenoscopic as well as by stereoscopic examination.

During the past three years we have conducted another case-finding program among the patients of the Clinic of Provident Hospital in Chicago introducing chest roentgenoscopy as a routine procedure in that institution.[2] The findings of

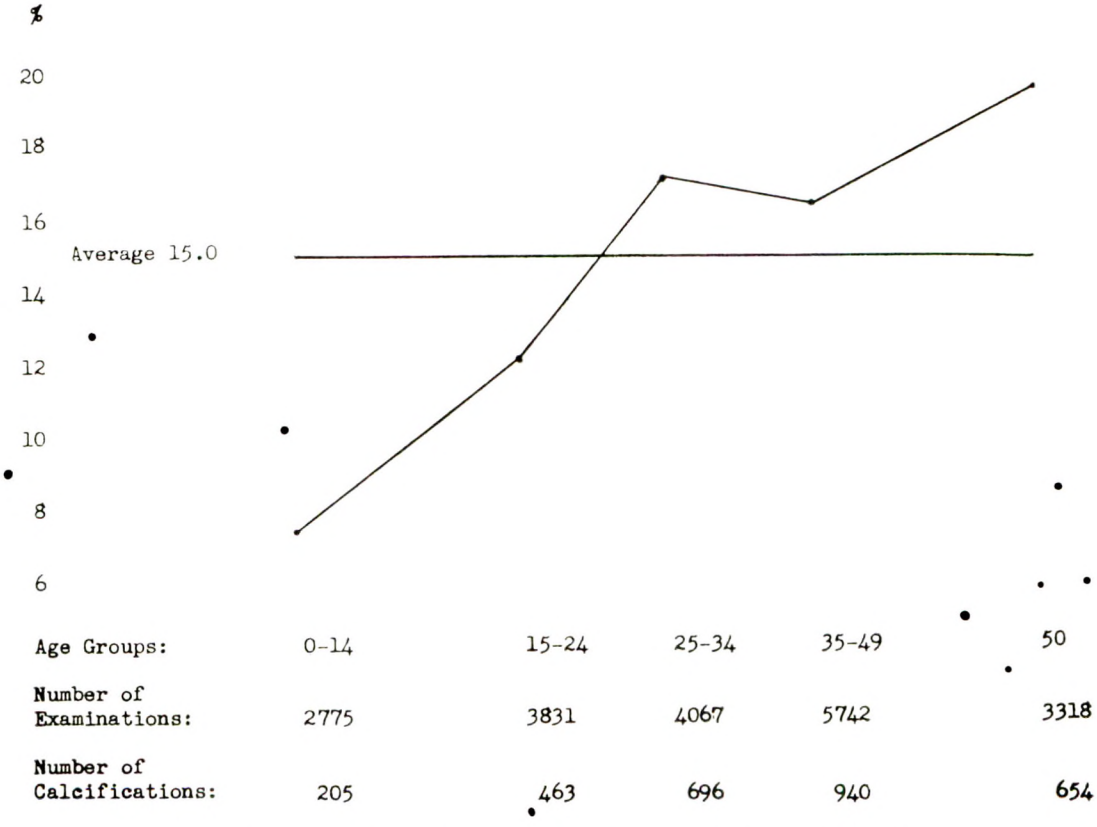


Fig. 2. Percentage of calcifications (Ghon's tubercles) in 20,000 Negroes.

calcified foci were recorded as to size, location, multiplicity of the lesion, and age of patient. In the first 20,000 Negroes of all ages who were examined there was again a sharp rise of the number of calcified foci with increasing age, as shown in Figure 2.

Realizing that a large number of such lesions, possibly their majority, are not discoverable by roentgenologic examination—the recorded average was 15 per cent—the groups are nevertheless representative. If failures of visualization could be corrected, the curve would probably rise still farther rather than decline, since failure of discovery is more likely to occur in the older and more obese groups than in the younger ones. It cannot be assumed that the majority of these foci would take from childhood to adulthood or even to middle age to reach the maturity of complete calcification. It was our observation, as it has been also that of others, that the average caseous lesion needs from six to eight years to reach a stage of calcification which makes it recognizable as such on roentgen examination. In childhood the period seems to be much less.

If the process of calcification consumes certainly less than a decade and if it is assumed to originate in childhood, why should we find so many more calcified tubercles among middle aged and old persons than in young adults and adolescents? In recent years much has been said about primary tuberculous infection in adults. With decreasing exposure of children to the tubercle bacillus, especially in some rural areas of the country, the occurrence of late primary infection has undoubtedly increased, but this shift is as yet of little significance in the general picture of tuberculous epidemiology, especially in the cities. Certainly in the middle aged and near-senile population the significance of first infection is to be denied. Primary adult infection, therefore,

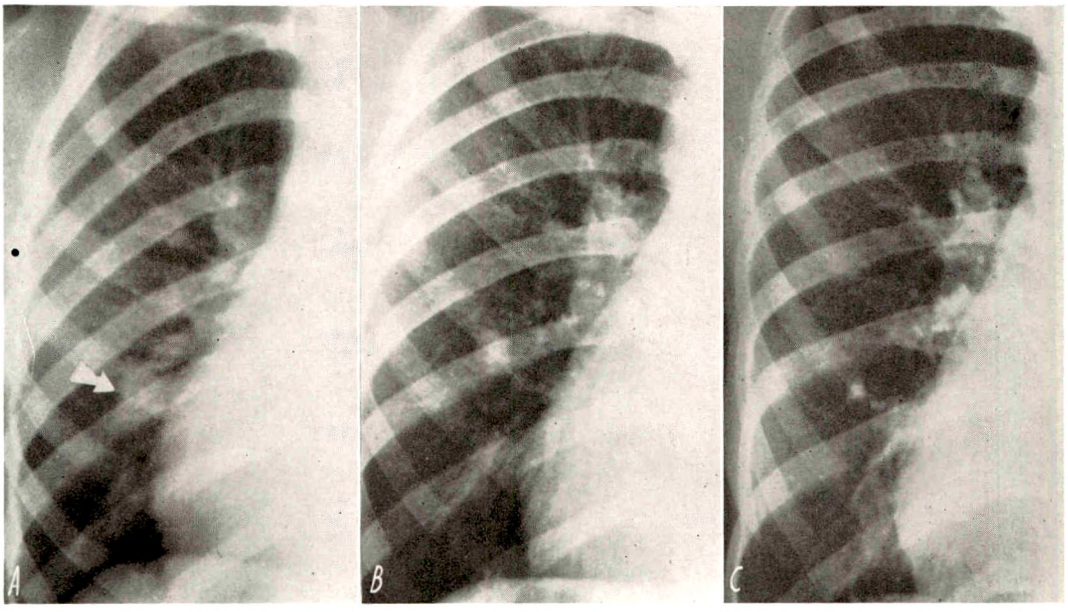


Fig. 3. Development of typical childhood (primary) focus. Unit No. 40866, B. T., female, aged six. Patient was exposed to infection from her mother who had pulmonary tuberculosis. *A*, taken in 1931, shows a fairly sharply outlined caseous focus near the left heart border. *B*, in 1933 the lesion appeared smaller, more sharply outlined, with a dense central focus representing calcification. *C*, in 1939 the peripheral area has been reabsorbed with the calcified nucleus remaining. Presumably the final stage was reached long before 1939 but no intermediate observations are available.

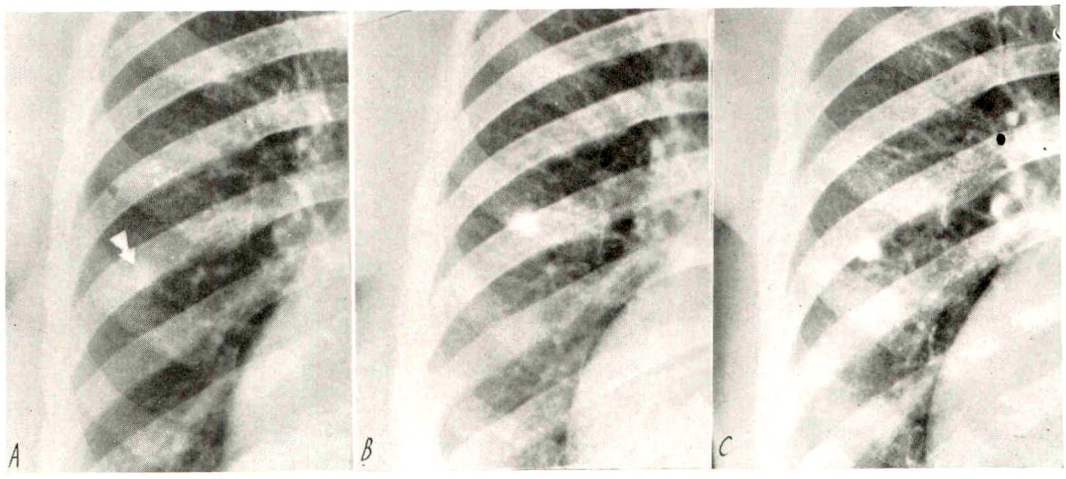


Fig. 4. Development of adult exogenous superinfection focus. Unit No. 8426, V. C., female, aged twenty-five. Patient was exposed to infection from her mother, who was found to have open pulmonary tuberculosis for some time before discovery of the daughter's focus. Patient was examined because of contact. A mild productive cough at the time of examination and recurring frequently after healing of the lesion was obviously related to upper respiratory infection. *A*, in 1929 an ill defined, small lesion was found in the left mid-lung field with round calcifying central area. *B*, in 1933 enlargement of the dense central area is still surrounded by a halo of lesser density. *C*, in 1936 there is complete calcification.

offers no answer to our question. The alternative is the assumption that a large number of calcified foci in the adult are not the remnants of a primary infection but rather the remnants of reinfection tuberculosis acquired during the adult age.

In recent years Ghon's student, Terplan,[8] in his studies on tuberculous foci has pointed out that reinfection can produce typical tuberculous complexes in the lung "heretofore considered as the characteristic sign of primary tuberculosis exclusively." In his anatomical observations he was not able to differentiate between the remnants of a second infection and the typical primary tuberculous focus. He stated that "the second complex . . . seemed to undergo the same regressive changes with encapsulation and chalky degeneration pointing to complete calcification as the ultimate result." Sweany[7] attempted the anatomical differentiation between the older and newer tuberculous foci on autopsy material and also demonstrated their development roentgenologically; the latter contribution showed that certainly in the roentgenogram the finished product of either variety is indistinguishable from the other.

Our own clinical and roentgenologic observations revealed great similarity and, in many cases, complete parallelism between the primary and assumed superinfection focus except for the previously mentioned difference in time which the average case of either variety consumes for the process of complete calcification (Fig. 3, 4, and 5).

In numerous examinations of persons who were known to have been exposed to recent tuberculous infection, mostly by family contact, small, usually caseous lesions were found in the lung fields on roentgen examination. Hardly any of these foci had caused symptoms, and they would not have been discovered at that stage but for a rule of the Chest Clinic to invite all contacts of our patients with active pulmonary tuberculosis to have a roentgen examination of the chest. Some of these small infiltrates were observed to disappear by reabsorption in the course of a few months or years. Others persisted

with slowly progressive encapsulation, deposition of calcium salts, and eventually calcification. It seems that many such patients, through excellent immunity, are able speedily to isolate the focus which has caseated after a localized infection has occurred in the lung tissue as the result of massive inoculation. The age of persons in whom these observations were made ranged up to sixty-seven years. In a few adults the formation of calcified foci was observed without any known preceding exposure to the organisms which could have caused the lesions by direct exogenous superinfection. In these patients the endogenous reinfection etiology can be assumed to be likely.

As in Terplan's observations, some of the lesions in question had developed in addition to pre-existing calcified foci in the lung parenchyma or the tracheobronchial lymph glands or both, thereby demonstrating their superinfection nature. From this it would follow that parenchymal calcifications found together with calcified glands may have resulted from an attack of infection different in time from that causing the development of the adenopathy. This would mean that the etiologic unity as to time, of a complex consisting of parenchymal and glandular involvement in the calcified state, cannot be taken for granted.

If the possible superinfection origin of the so-called Ghon's tubercle can be considered as established, it is only a step to the speculation that even a child's calcified focus may not be the remnant of a

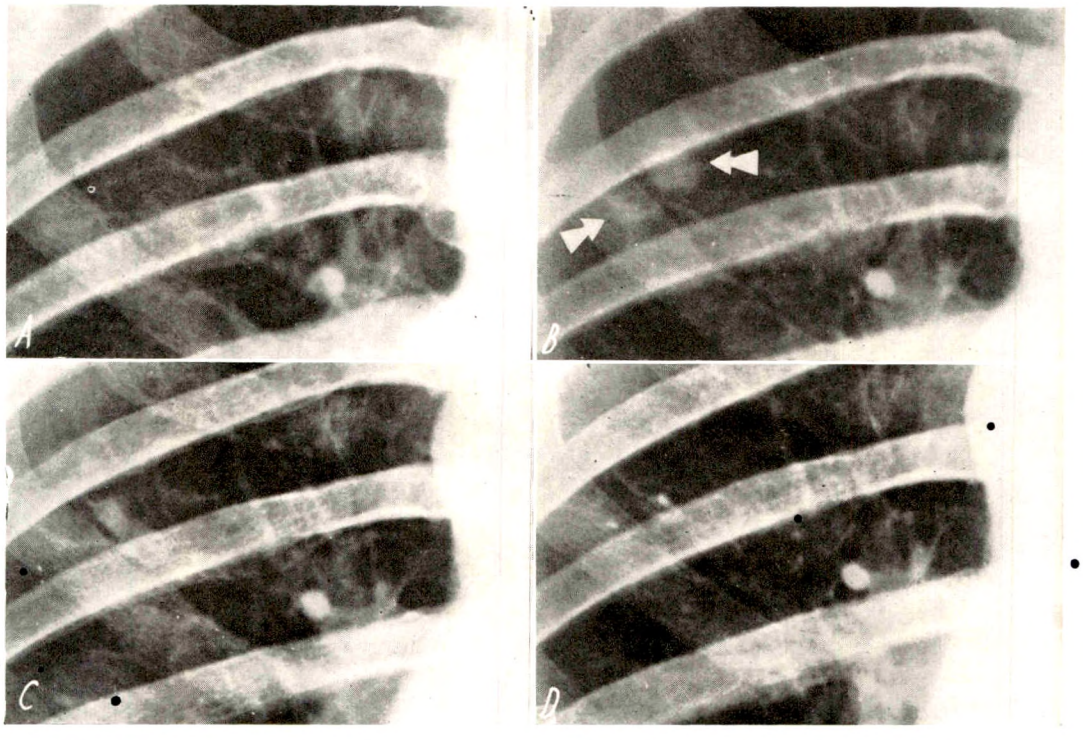


Fig. 5. Development of adult—possibly endogenous—reinfection foci. Unit No. 15600, M. P. H., female, aged thirty. Several members of the immediate family had pulmonary tuberculosis but there was no known contact for some time preceding discovery of the lesions. *A*, roentgenogram taken in 1929 on occasion of a general examination failed to show pulmonary involvement. *B*, in 1939 two irregularly shaped but sharply outlined foci of little density in the left subapical area. At that time patient had mild systemic symptoms. *C*, in 1933 the foci were more sharply circumscribed and of greater density. Patient was clinically well at that time. *D*, in 1937 there was complete calcification of the foci, then much reduced in size.

first infection in the strict sense of the word. Some of us have long abandoned the concept of a single inoculation from which primary lesions result, and prefer to speak rather of a primary infection period during which several or many inoculations with the tubercle bacillus occur, one of which, but not necessarily the first one, results in the petrified tubercle; in other words, even the true Ghon's tubercle of early life may be the expression of a reinfection superimposed on the truly first lesion which we know frequently is absorbed, leaving no macroscopic residuals.

CONCLUSIONS

It seems logical on the basis of such evidence that a re-evaluation of the so-called Ghon's tubercle or primary tuberculous calcification is needed. In the light of our present knowledge, the only justifiable interpretation that can be placed on the finding of a calcified tuberculous lesion by roentgen examination is that it represents the innocuous residual of a tuberculous infection, either a primary infection or reinfection at some prior time, either in childhood or adulthood, without its being possible to determine the time at which the infection occurred.

Therefore the term, "Ghon's tubercle" should either be dissociated entirely from the time element and applied to all small calcifying or calcified tuberculous foci regardless of age, or if it is to be retained as signifying the residuals of a childhood infection it should be applied only when the calcified residuals are found in the child.

SUMMARY

1. The childhood origin of all so-called Ghon's tubercles is to be doubted.

2. Through large scale pathologic and roentgen examinations, the greater incidence of calcified foci in higher age groups has been established.

3. The majority of such lesions originating during adult life can be traced to exogenous superinfection of individuals who are known to have been exposed to infection as adults.

4. Serial roentgenographic evidence of the development of calcifying foci in adults is presented.

5. They cannot be differentiated from childhood (primary) lesions.

6. The concept of the true primary nature even of the childhood calcification can be doubted.

7. The term, "Ghon's tubercle," should be dissociated from the time at which the infection occurred or should be limited to foci found in children only.

REFERENCES

1. Bloch, R. G., Francis, B. F., Eisele, C. W., and Mason, E. W. Roentgenological group examinations for pulmonary tuberculosis. *Am. Rev. Tuberc.*, 1938, *37*, 174–199.
2. Bloch, R. G., Tucker, W. B., and Bryant, J. E. Roentgenologic group examinations for pulmonary tuberculosis in Negroes in Chicago; preliminary report. *J. Am. M. Ass.*, 1940, *115*, 1866–1873.
3. Carnes, W. H. Present incidence of tuberculous infection. *Bull. Johns Hopkins Hosp.*, 1942, *70*, 101–123.
4. Ch'iu, P. T. Y., Ho, E. A., and Li, C. C. Incidence of tuberculous infection and pulmonary tuberculosis among 8,282 Chinese with special reference to students in Peiping. *Chinese M. J.*, 1940, *58*, 556–569. Quoted from Abstracts in *Am. Rev. Tuberc.*, 1941, *44*, 51.
5. Ghon, A. The Primary Lung Focus of Tuberculosis in Children. English edition, J. and A. Churchill, London, 1916.
6. Schürmann, P. Der primärkomplex Rankes unter den anatomischen Erscheinungsformen der Tuberkulose. *Virchows Arch. f. path. Anat.*, 1926, *260*, 664–855.
7. Sweany, Henry C. Age Morphology of Primary Tubercles. Charles C Thomas, Springfield, Ill., 1941.
8. Terplan, K. Anatomical studies on human tuberculosis. *Am. Rev. Tuberc.* (Supp.), 1940, *42*, 1–176.

emulsion is superimposed upon the sharper image of the first emulsion which accounts for the considerable unsharpness of detail when using the old type roentgen films for photographing the fluoroscopic image.

Another advantage of the single coated film is the greater latitude and range in gradation of densities. This is true because there are two emulsions coated one on top of the other. Hence we are less apt to lose detail in the outer zone when the central zone is overexposed.

The arrangement of the lens in the camera is such that there is greater concentration of light in the central zone. This is seen on the old type film as a dark central area. The increased latitude in single coated films offsets this disadvantage to a great extent and the film shows a more even exposure. This film has less contrast than the old type double coated and requires the use of a stationary grid to diminish secondary rays and build up contrast.

All these factors tending to improve the film must be compensated for by increase in kilovoltage or milliampere-seconds. The miniature film takes about 10 kv. more than the conventional 14×17 inch film; the use of the grid requires either doubling the milliampere-seconds or another increase of from 10 to 12 kv. The single coated emulsion film also requires an increase of about 4 kv. All this throws a greater burden on the tube and shorter life must be anticipated than on the conventional roentgen-ray installation.

The diagnostic value of these smaller films has been excellent, and it is only in the exceptional case when the individual measures over 30 cm. that a 14×17 inch film is taken. It has never been necessary to take a 14×17 inch film in order to check a doubtful shadow. The stereoscopic shift giving two views clarifies doubtful shadows, throwing small shadows obscured by the ribs in one view into the interspace in the other. De Lorimier rated the 4×5 inch stereoroentgenogram of greater diagnostic value than the single 14×17 inch film. In his experience he found that early lesions of reinfection tuberculosis are made more conspicuous on the miniature films than when projected into the larger dimensions of the 14×17 inch film.

This increase in sharpness is easily understood when we realize that the grain of the fluorescent screen is reduced in proportion of 14×17 to 4×5 inch. This view of the greater efficiency of the 4×5 inch film is also shared by Christie[1] who states that for minimal lesions he feels more certain of their detection by means of two 4×5 inch films made with a tube shift than with a single 14×17 inch film of the best quality. Shifting of the tube serves to uncover portions of the lungs which may have been obscured by bones or other structures in the roentgenogram. It is the minimal lesion which is most significant. Large lesions can be easily demonstrated on any type of procedure. If the case should require further study, the stereoscopic film is available.

Another factor favoring the 4×5 inch film is that they can be interpreted with less fatigue for the roentgenologist. As de Lorimier states, the scope of the visual concentration is limited and a study of a 14×17 inch film is comparable to viewing 6 to 8 miniature films. This is an important factor in survey work where from 200 to 400 films are to be diagnosed daily. Viewing small dimensions requires fewer fields of visual concentration and the increased sharpness of densities in the lung makes them more conspicuous. His conclusion is that the miniature stereo films are best for a case finding procedure.

For diagnostic purposes, oblique and lateral views on conventional sized films can be obtained.

Diagnostic accuracy has been checked by others in comparative studies of the 4×5 inch film versus the 14×17 inch. Potter, Douglas and Birkelo[9] found the percentage of error as 2.6 on the 4×5 inch film among 271 cases checked by the large film. In nearly every instance the minimal lesions were superimposed over rib shad-

VOL. 49, NO. 4

TEN THOUSAND CHEST EXAMINATIONS WITH THE STEREOSCOPIC PHOTOROENTGEN UNIT*

By JOSEPH LEVITIN, LIEUTENANT COLONEL, M.C.
Roentgenologist, San Francisco Recruiting and Induction District
SAN FRANCISCO, CALIFORNIA

THE problem of tuberculosis in the Army is the discovery of the minimal lesions that exist without symptoms. Many of these lesions are latent and might remain so under ordinary conditions of life. In Army life, fatigue and a lowered resistance may activate these latent foci, so that the individual in question may become a casualty and a burden on the government for the rest of his life. It is estimated that each case of tuberculosis in the last war cost the government between $10,000 and $15,000, the total cost reaching over one billion dollars.

The best way to detect these latent lesions is by roentgen examination.[5,12] Physical examination alone is inadequate, for physical signs in most instances are lacking. Moreover, chest surveys by the roentgen ray are not new. The reader is referred to the excellent articles by Robins and Ehrlich[11] who examined 20,000 in New York City using an emulsion on a paper base; by Richards,[10] who reported on over 300,000 cases, examined for the Canadian Army using 14×17 inch films; and by Edwards and Ehrlich,[4] who reported on over 50,000 inductees and National Guardsmen in New York City using the paper roll. Pindell[6] recently reported a series of 2,107 cases using the photoroentgen unit and taking 4×5 inch single films. All agree that group survey by roentgen examination of the chest is satisfactory, the results justifying the work and expense involved.

The photoroentgenoscope used at this station is made by the General Electric Corporation. Films are taken stereoscopically. The apparatus and the technique of its use are described in the excellent articles by Potter[7,8] who collaborated with the General Electric Corporation in its development; by Lieutenant Colonel de Lorimier†,[2] who was instrumental in its development for the Army, and by Pindell.

In the past questions were raised respecting the diagnostic accuracy with which the 4×5 inch film could be used—such questions being directed essentially at the technical qualities of density, contrast, and detail, and the influence they have on the readability of a film. To obtain the best results with 4×5 inch film, time, experience, and improvements show that consideration must be given to the use of the proper type of developer and film and to the use of a fine, stationary grid.

In the first place ordinary developer would necessitate a long developing time which increases the chemical fog. High speed developer shortens the developing time so that six minutes at 65° F. can be used and chemical fog can be avoided.

Second is the use of the single coated film. It gives better detail because there is one image instead of the two present on the double coated film. The significance of this was pointed out by de Lorimier[3] who brought out the fact that we are dealing with light waves from the fluorescent screen to sensitize the emulsion on the film rather than roentgen rays. When the double coated film is used the light waves are refracted when passing through the front layer of film emulsion and through the film base. About 30 per cent of this light goes through the film, finally to become effective upon the back layer of emulsion. The blurred image of the second

* This paper is published with permission of the Surgeon General, War Department, U. S. Army, who assumes no responsibility for statements made or conclusions reached herein.

† Director of the Department of Roentgenology in the Army Medical School.

ows in the small film. This, of course, is obviated by the two views obtained with the stereoscopic shift. The reverse now holds true, a small lesion missed behind a rib in a single 14×17 inch film is thrown into the interspace by the different position on the stereoscopic film. Ezra Bridge (quoted by Pindell)[6] also reported on the examination of 1,000 patients at Iola Sanatorium with the 14×17 inch film and the small 4×5 inch film. Of the 130 minimal cases found, 2, or 1.5 per cent, were missed on the miniatures. At that time a system for producing or using the stereofilm was not available.

A strict comparison of results of interpretation of the 4×5 inch films with 14×17 inch films is difficult. If the results of one individual reading 4×5 inch films is compared with that of one reading the same cases of 14×17 inch films we must take into account the error inherent in the individual. No two individuals would read 1,000 roentgenograms alike, and even the same individuals would read the same 1,000 roentgenograms with some changes at different times. The factor of fatigue of the roentgenologist also enters. Richards, reporting on chest roentgen examinations of the Canadian Army found that 11 cases out of 328,325 were missed, or a percentage error of 0.003. In each instance the lesion was overlooked by competent men and all agreed the lesion was present when the roentgenogram was reviewed. This percentage is admittedly low but it is based on only review of those cases which subsequently showed active tuberculosis. They do not know how many were missed in the group that did not become active.

The accuracy of either type of case finding procedure cannot be judged by the results obtained if the same individual read a series of 4×5 inch films and a comparable series of 14×17 inch films on the same cases.

Unless the series is large, the roentgenologist could not help but carry a visual memory of the few positive and doubtful of the first series in his mind, and subconsciously look for them in the second series. No one, to date, has reported a series large enough to avoid such an error.

An idea as to the accuracy of the stereo 4×5 inch film as compared to the 14×17 inch film may be gained by a comparison of the percentages of reinfection tuberculosis found if the material is based on the same cross section of population. This has added accuracy if they are reviewed by the same individual.

Before the photoroentgen unit was established at this station, the men were sent to private roentgenologists for 14×17 inch single chest roentgenograms. I had the opportunity of reviewing 2,410 of these roentgenograms. The incidence of reinfection tuberculosis in this group was 1.2 per cent. This compares to 1.36 per cent found on the stereo 4×5 inch roentgenograms based on 10,000 cases examined at this station. This difference does not imply that the 4×5 inch films are 0.16 per cent more accurate. The sampling error in each group must be considered and their result compared.

The statistics of each group were analyzed by Dr. E. L. Lucia and her conclusion was that there is no difference in the effectiveness of diagnosis between the two types of film.*

* In sample I a positive rate of 13.6 per 1,000 was observed among 10,000 examinations made.

In sample II, the number of positives was 12.0 per 1,000 among 2,410 examinations.

The difference between these two rates is 1.6 per 1,000.

To determine whether or not this difference is significant, it is necessary to calculate the sampling errors for each of these rates.

The formula reads:

$$\sigma_{p_1} = \sqrt{\frac{p_1 q_1}{n_1}}$$

where p_1 (the chance of success) is 13.6 per 1,000 and q_1 (the chance of failure) is 987.4 per 1,000, or the difference between 1,000 and the chance of success: $1{,}000 - p_1 = q_1$.

By substituting the values for sample I, we have

$$\sigma_{p_1} = \sqrt{\frac{13.6 \times 987.4}{10{,}000}} = \sqrt{1.34} = 1.158.$$

The rate may be written as 13.6 per 1,000 ± 1.158.

Similarly substituting the values for sample II, we have

$$\sigma_{p_2} = \sqrt{\frac{12 \times 988}{2410}} = \sqrt{4.92} = 2.218.$$

The rate may now be written as 12 per 1,000 ± 2.218.

The formula for the sampling error of the difference of proportions is as follows:

$$\sigma_{p_1 - p_2} = \sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}.$$

By substituting the squares of the values obtained for the sam-

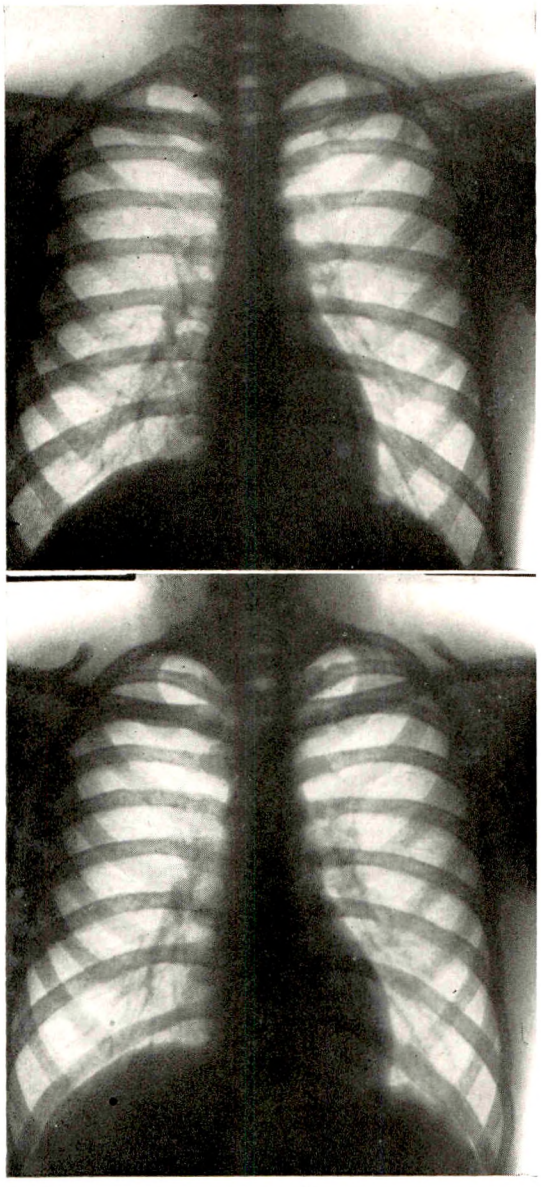


Fig. 1. Normal chest. Stereoscopic roentgenograms taken on a single 4×10 inch film; single coated emulsion. To be viewed on the orthostereoscope specially designed for the purpose. The image is magnified about twice by the stereoscope.

In addition to the accuracy of the diagnosis and less fatigue in its interpretation, another factor of importance to be considered where we are dealing with surveys of large numbers is the ease of handling the smaller film which requires less developing, drying space and storage room.

This report is based on 10,000 consecutive roentgenograms of chests of men coming for final type physical examination prior to induction in the United States Army. All have had a preliminary screen examination by their local draft board. Those obviously suffering from or being treated for conditions exempting them from the Army are not sent in. In addition to this group making up the series are a small number of those seeking enlistment. It can be stated that the group is made up of men considered as fit applicants for military duty. *Not one is receiving a chest roentgenogram because he requires it.*

The roentgenograms are interpreted as

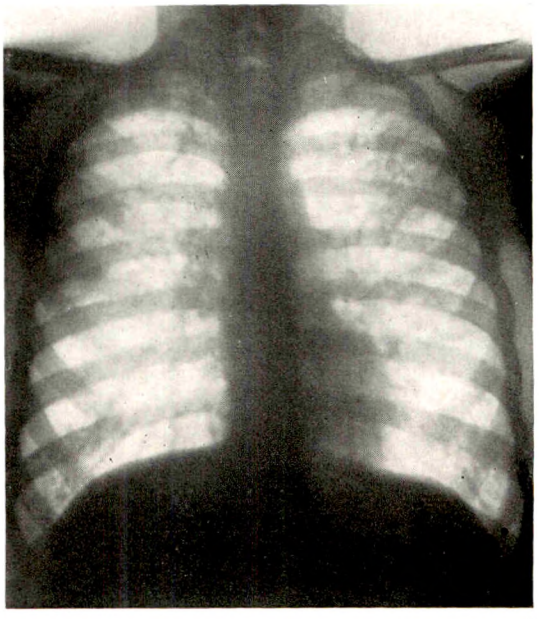


Fig. 2. The only complaint of this individual was laryngitis. The roentgenogram shows a large cavity measuring about 8 cm. in diameter at the right apex with nodulations and fibrosis of the right upper lobe. Fibrosis and nodulation involving the left upper lobe. The roentgenogram was taken on the double coated emulsion. In comparing with Figure 1, note the hazy outline of the vascular markings and the lack of sharpness of the ribs. The roentgenogram also shows more contrast, but poorer detail.

pling of p_1 and p_2, we find $\sqrt{1.34+4.92}=\sqrt{6.26}=2.5$

The difference between 13.6 and 12.0 which is 1.6 has been found to have a sampling error of 2.5, a value greater than the difference itself. From the standpoint of the statistical analysis it is customary to state the sampling error of the difference of 2.5 that the difference should be at least 7.5 to be signifiacnt, all other things being equal. A difference of 1.6 may therefore be said to have no significance whatsoever. Dr. E. L. Lucia.

Associate Professor of Biometry, Department of Hygiene, University of California.

to primary tuberculosis and reinfection type. All reinfection types are disqualified for unlimited service even though healed. The primary types with calcifications were accepted for the first 6,927 cases. A later ruling disqualified those with calcifications where there were more than five calcified hilar glands or where one has a diameter of 1.5 cm. or larger (measured on the 14 × 17 inch film). Also eliminated were those with parenchymal calcifications of more than five in number and where one measured 1 cm. in diameter or larger (14×17 inch film).* The cases with these calcifications, although rejected, are tabulated under calcified lesions.

All cases showing reinfection tuberculosis were grouped as to whether they appeared healed or active on the roentgenogram. It is admittedly dangerous ground to determine activity on the roentgen appearance of the lesion. The leaning was toward conservatism in the diagnosis of healed lesions. All lesions that were calcified, or showed sharply demarcated strand-like infiltration, were considered as healed.

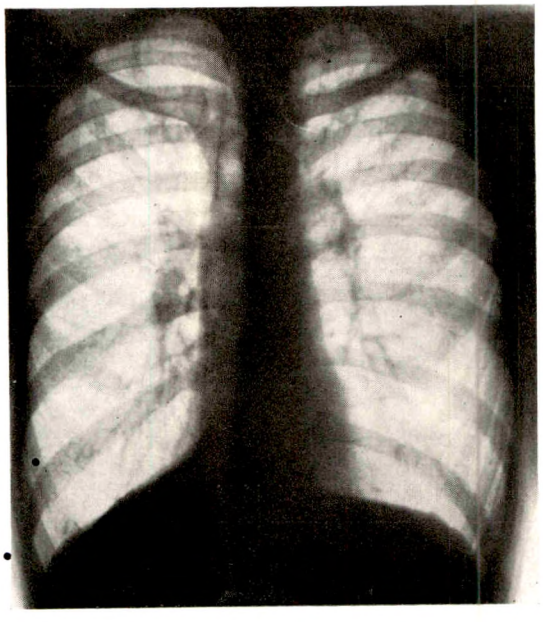


Fig. 3. This individual has been under treatment by various doctors for asthma for the past four years. No one had ever ordered a roentgen examination of the chest. The roentgenogram shows extensive fibrosis involving both lobes. The heart is small, with the mediastinal structures displaced to the right. (Single coated film.)

* Latest ruling allows ten calcifications in the parenchyma.

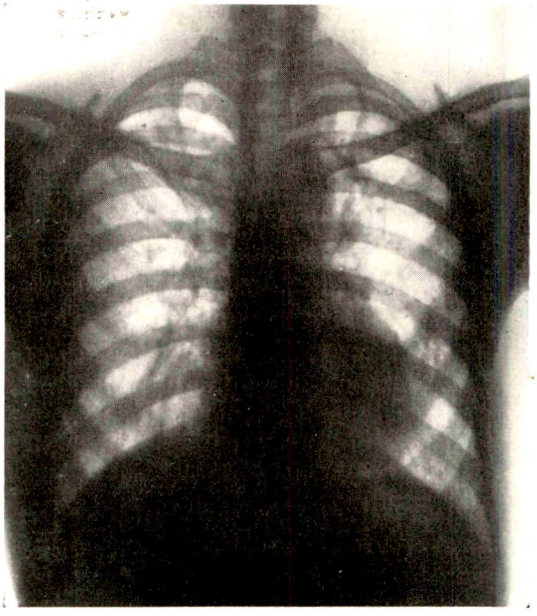


Fig. 4. This individual had no complaints or previous history of illness. He is a food handler of uncooked vegetables. Both upper lobes show considerable fibrosis. Cavity about 7 cm. in diameter at the left apex; one 3.5 cm. in diameter at the right apex. (Single coated film.)

All others were considered active, even though many are cases of arrested tuberculosis. This is the important group with which we are concerned from a public health standpoint and control of tuberculosis. The active and the arrested cases are the ones either spreading the disease or the ones likely to break down. The healed and calcified cases are of interest for statistical purposes. Active and arrested cases were the ones with soft nodulations, calcifications with periphery of lesser densities fading into the normal parenchyma and cavities.

The histories of all reinfection type tuberculosis were obtained and data noted as to whether or not the individual ever had any symptoms or signs pointing toward a chest lesion. Positive histories were pleural effusion, hemorrhage, cough, loss of weight, fatigue, and past treatment for tuberculosis. A history was called nega-

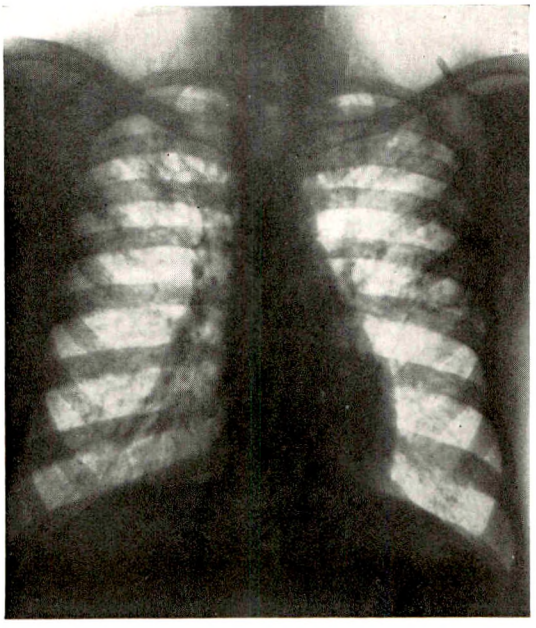


Fig. 5. This individual had no complaints or previous history of illness. He is a food handler of uncooked vegetables. Extensive nodulations and fibrosis of both upper lobes. Cavity about 2 cm. in diameter in the sixth interspace at the left axilla and one beneath the right clavicle. (Single coated film.)

tive when the individual had had no symptoms at any time referable to his chest.

It was astonishing to find the number of men with active tuberculosis having no suspicion of the disease. Fourteen had cavities and had been passed up as 1A in their routine physical examination. One had an extensive tuberculosis and his only complaint was a laryngitis (Fig. 2). Another had been treated for asthma for four years and had a fibrous tuberculosis. He had never been roentgenographed (Fig. 3). Also of interest were the number with cavities who were food handlers (Fig. 4 and 5).

Those rejected for chest conditions have their roentgenograms returned to their local draft board.* They are available to the men so that they may get proper treatment.

All rejected cases at this station are reported to the San Francisco Department of Health. In return they report out of town cases to the State Department of Health. Of the first 69 cases of reinfection tuberculosis, residents of San Francisco County, reported to the Department of Health, 8 were hospitalized, 10 were sent to their private physicians, and 8 were unable to be located. The rest were being treated in the clinic.

The results of the first 10,000 cases studied are shown in Tables I, II, III and IV.

DISCUSSION

Those active cases of tuberculosis which have had a positive previous history should give us no concern. They are a problem of a closer follow-up system for those who have been treated, or further education of the public for those with symptoms to consult a doctor. A survey of medical facilities, to see if they are available for those with symptoms, should bring these cases under control. This number is the smallest of the whole group, only reaching 2 per 1,000.

Table I

	Total No.	No. per 1,000 Population
Reinfection tuberculosis	136	13.6
Calcifications, hilar and/or parenchymal	536	53.6
Other lung lesions	13	1.3
*Cardiac abnormalities	45	4.5
Dextrocardia	3	.3
Anomalies		
Vena azygos lobes	15	1.5
Cervical ribs	64	6.4
Anomalies of ribs; fused, bifid	19	1.9

* It is beyond the scope of this paper to analyze the cases of cardiac abnormalities; a subsequent report will tabulate the number of cardiac rejections with normal roentgen findings, abnormal cardiac roentgen findings with normal clinical findings and the abnormal group where they both agree.

Table II

Calcifications: total 536.0 in 10,000 cases
Rejected because of too many or too large in 3.313 cases
Total 16.0 = 4.8 per 1,000 population

* A new ruling sends roentgenograms of all rejected cases to the Director of State Selective Service.

TABLE III

LUNG LESION OTHER THAN TUBERCULOSIS
TOTAL NO. = 13

	No. per 1,000 Population
Pneumoconiosis	0.1
Bronchiectasis	0.3
Tumor	0.1
Metastatic malignancy	0.1
Pleural thickening	0.5
Substernal thyroid	0.1
Atelectasis	0.1

TABLE IV

REINFECTION TUBERCULOSIS. TOTAL REJECTED 136

	No.	Percentage of All Tuberculosis Cases	Per 1,000 Population
A. Healed	65	47+	6.5
Active	71	52+	7.1
B. Previous history of tuberculosis	46	33+	4.6
No history	90	66+	9.0
C. Positive history 46 cases			
Active	20	14+	2.0
Healed	26	19+	2.6
D. No history 90 cases			
Active*	51	37	5.1
Healed	39	28	3.9

* 14 active cases had cavities; 1.4 cases with cavities per 1,000 population.

The healed cases, likewise, are of no immediate problem. The number that have healed never being aware of their disease is 50 per cent greater than those who have been treated.

What is of significance, from the public health standpoint and to the individual, are the 5 cases per 1,000 going about with active lung disease without symptoms, unaware of their illness. That this can be extensive is evident on some of the cases examined. Twenty-eight per cent of this group have cavities.

CONCLUSIONS

1. Roentgen examination offers the best present method of detecting the small minimal tuberculous lesions.

2. The 4×5 inch stereo film is the most satisfactory for chest surveys. It is more economical and easier to handle than the conventional single 14×17 inch film and has the same, if not better, diagnostic accuracy.

3. The incidence of reinfection tuberculosis in a cross section of healthy adult male population between the ages of twenty-one and thirty-five is between 1.2 and 1.35 per cent. Of this group over 50 per cent are active or have an arrested disease. Two-thirds of those with reinfection tuberculosis are not aware of having or having had the disease.

4. Widespread tuberculosis with cavitation can be present without symptoms.

REFERENCES

1. CHRISTIE, A. C. Evaluation of methods for mass survey of the chest. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *47*, 76–82.
2. DE LORIMIER, A. A. X-ray examinations of the chest for the United States Army. *Med. Clin. North America*, 1941, *25*, 1773–1798.
3. DE LORIMIER, A. A. Mass roentgenography of the chest for the United States Army. *Radiology*, 1942, *38*, 462–472.
4. EDWARDS, H. R., and EHRLICH, D. Examinations for tuberculosis; roentgenographic findings of 41,809 inductees and 9,541 National Guardsmen in New York City. *J. Am. M. Ass.*, 1941, *117*, 40–45.
5. LONG, E. R. Symposium on medical preparedness; problem of tuberculosis in military service. *J. Am. M. Ass.*, 1941, *117*, 264–266.
6. PINDELL, M. L. Photoroentgenography in a tuberculosis program. *Radiology*, 1942, *38*, 224–231.
7. POTTER, H. E. Miniature films in chest surveys. *Radiology*, 1940, *34*, 62–65.
8. POTTER, H. E. Technical factors underlying miniature roentgenography of the chest. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *47*, 71–75.
9. POTTER, H. E., DOUGLAS, B. H., and BIRKELO, C. C. Miniature x-ray chest film. *Radiology*, 1940, *34*, 283–291.
10. RICHARDS, G. E. A discussion on surveys of the film as used in the Canadian Army. AM. J. ROENTGENOL. & RAD. THERAPY, 1942, *47*, 66–70.
11. ROBINS, A. B., and EHRLICH, D. E. Group x-ray surveys in apparently healthy individuals. *Radiology*, 1940, *34*, 595–607.
12. SPILLMAN, R. Value of radiography in detecting tuberculosis in recruits. *J. Am. M. Ass.*, 1940, *115*, 1371–1378.

THE ROENTGENOLOGIC DIAGNOSIS OF DILATATIONS OF THE SPINAL CORD VEINS*

REPORT OF A CASE

By BERNARD S. EPSTEIN, M.D., *and* LEO M. DAVIDOFF, M.D.
BROOKLYN, NEW YORK

VENOUS dilatations of the spinal cord is an uncommon condition which is difficult to diagnose clinically. Routine roentgenographic examinations of the spine offer no help. In 1927 and 1929 two cases were reported in which iodized oil myelography revealed a peculiar distribution of droplets of oil over two or more vertebral segments.[3,7] These were the first instances in which the roentgenographic findings were important. Black and Faber[1] reported a case in which the appearance of a Froin syndrome, a Queckenstedt test changing from negative to positive after removal of spinal fluid from below the lesion and alterations in the distribution of iodized oil within the spinal canal as seen on myelograms was believed indicative of spinal venous dilatations. Buchanan and Walker[2] also noted a peculiar distribution of oil within the spinal canal in a patient five years old. They did not consider this appearance characteristic of any specific entity.

Intraspinal vascular dilatations may occur as true dilatations of the pial veins, as arterial or arteriovenous aneurysms or as hemangiomas. Because individual instances of arterial or arteriovenous aneurysms can be distinguished only with difficulty from true venous dilatations these two groups can be separated only on morphologic differences. They occur with approximately equal frequency and form 90 per cent of the cases reported.[4] The hemangiomas form a separate group and are neoplastic.

One of the two usual explanations offered for the presence of non-neoplastic venous dilatations is the existence of some interference in the spinal venous circulation which results in varix formation. This concept is supported by the findings recently reported by Hare and Everts.[5] They describe a patient who developed calcifications within the spinal canal after an injury. Twenty-five years later varices were found above the calcific area at operation, and they concluded that slowing of the venous circulation by pressure of the lime salt deposit had resulted in the formation of varices. The second explanation is the presence of congenital anomalies in the development of the veins resulting in angiomas.[8] The case we are reporting probably falls into the latter group.

The importance of the condition depends on the extent of the dilatations and the resultant increase in intraspinal pressure. Minute dilatations may exist without producing symptoms, such as have been mentioned by Kaydi[6] in patients who had no evidence of central nervous system disease.

The distribution of iodized oil within the spinal canal offers a roentgenologic approach to the diagnosis which is worthy of more detailed description. The dilated veins lie in the spinal canal surrounded by the cerebrospinal fluid. Depending on the degree of engorgement, various pressure points may be produced within the spinal cord and the circulation of the spinal fluid may be impeded. Inasmuch as the veins may on occasion be dilated and at other times collapsed, a constant roentgenographic picture should not be anticipated. If the fluid is displaced by the iodized oil, the varices dilated at the time show up as a pattern of negative serpentine shadows

* From the Radiologic Service of M. G. Wasch, M.D., and the Neurosurgical Service of L. M. Davidoff, M.D., The Jewish Hospital of Brooklyn.

because the oil cannot cover the dilated veins.

We are presenting a fifth case with roentgenographic findings. The diagnosis was established preoperatively by one of us (L. M. D.) on the basis of the myelograms.

REPORT OF CASE

J. S., male, aged forty-three, had noted pins and needles sensations over the right buttock and the right lower extremity for eleven years. The onset of the paresthesias was sudden, and the initial attack lasted two weeks and then disappeared spontaneously. Since then there had been frequent recurrences varying from a few minutes to several hours in duration and of varying degrees of pain. These episodes appeared without apparent cause and disappeared without sequelae. The patient had noted difficulty in starting and stopping his urinary stream for about ten years before admission. Five years ago cystoscopic examination and examination of the prostatic secretion were reported as normal.

The patient remained in relatively good health until one year ago. At that time he noted weakness of his right lower extremity and stumbled frequently, most often with his right foot. Two weeks before admission dull constant pain in the lower spinal region appeared, and one week later there was numbness without paresthesia of the right lower limb. The day before admission numbness appeared in the left foot. He had had three episodes of uncontrollable shaking of the right lower extremity during the five months before admission. Each episode lasted about five minutes.

Physical Examination. The patient was well developed and nourished. He walked with difficulty, his right leg was stiff and he shuffled his right foot along the ground. There was a positive Romberg sign, although he did not fall to any particular side. The motor power of the neck, upper extremities and trunk was good. There was weakness of both lower extremities, particularly in the right hamstring group. Moderate hypesthesia from the level of the seventh and eighth thoracic segments to the first lumbar segment anteriorly and posteriorly was present. Below the first lumbar segment the hypesthesia was less marked. The perception of vibration was absent from both lower extremities, and just perceptible at the anterior iliac spines. There was loss of position sense of the big toes. The finger-to-nose test was performed satisfactorily. The heel-to-knee test showed marked loss of position sense bilaterally. There was no dysdiadokokinesia.



Fig. 1. "Spot" roentgenogram taken under roentgenoscopic control demonstrating a large varix in the lower cervical region. The varix is outlined by the parallel serpentine distribution of the iodized oil. A smaller varix is seen in the mid-cervical and upper thoracic region.

Examination of the cranial nerves showed no evidence of abnormal responses. The Babinski reaction was doubtfully positive on both the right and left sides. The knee jerks, ankle jerks, biceps, triceps, radial and ulnar reflexes were intact. There was tenderness over the spine from the twelfth thoracic to the fourth lumbar

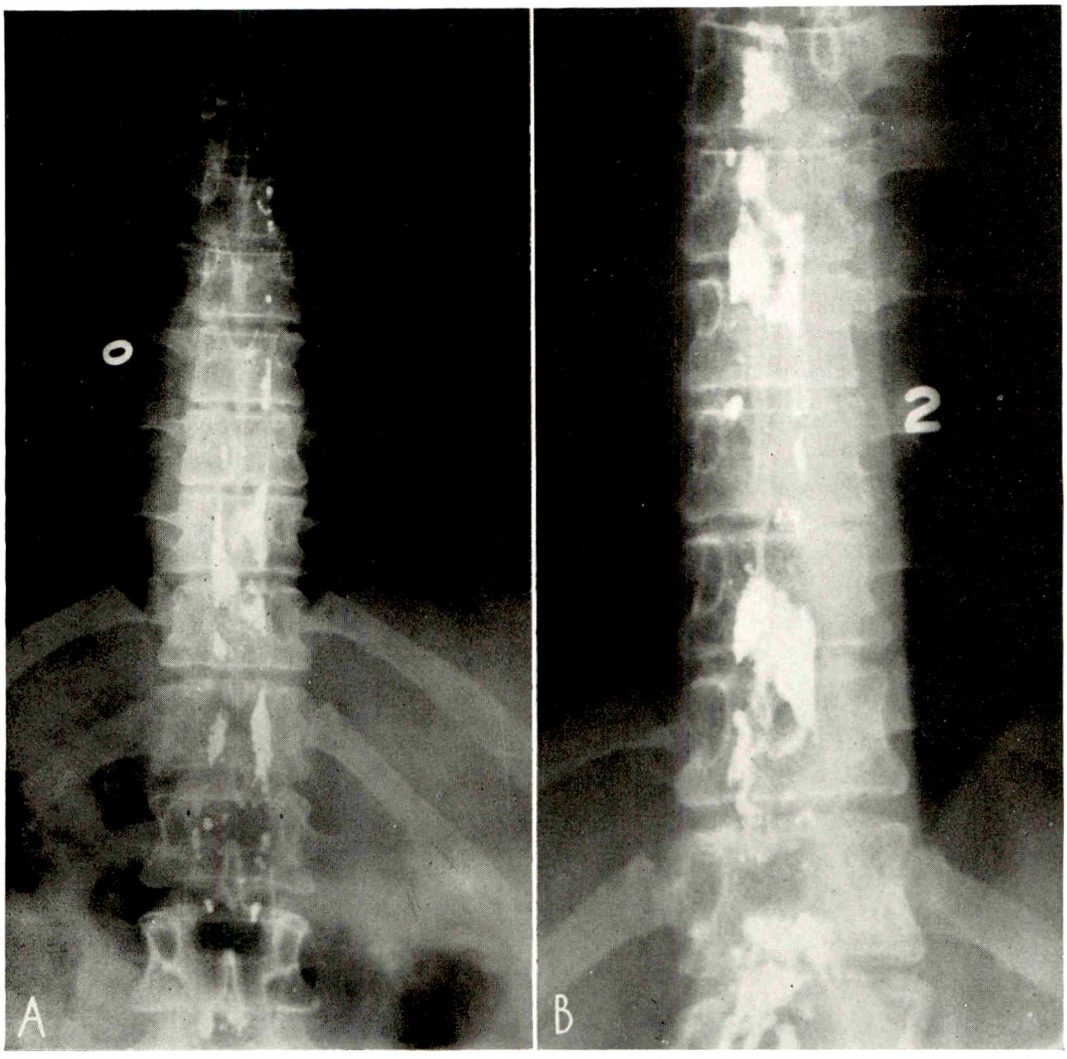


FIG. 2. *A*, "spot" roentgenogram showing varix at the level of the tenth, eleventh and twelfth thoracic vertebrae. *B*, roentgenogram taken three days later showing alteration in the distribution of the iodized oil. Another varix at the level of the seventh thoracic vertebra can be demonstrated.

vertebrae. The rectal sphincter tone was good. The abdominal reflexes were absent.

Spinal tap showed an initial pressure of 138 mm. of water, which fell to 84 mm. of water after the withdrawal of 10 cc. of fluid. There was no evidence of manometric block. The total protein was 120 mg. per 100 cc. Globulin was 2 plus. The Wassermann reaction was negative.

Direct roentgenographic examination of the spine showed no evidence of an osseous pathological condition. The measurement of the interpedicular spaces according to the Elsberg and Dyke curve was normal.

Examination of the spine after the introduction of 2.5 cc. of iodized oil showed no evidence of block. Roentgenoscopic inspection revealed free flow of oil from the caudal sac to the cervical region. Roentgenographic examination revealed the presence of numerous negative shadows with smooth, parallel sides. These were present in the lumbar, thoracic and cervical regions, and measured up to 1 cm. in width. The findings were interpreted as due to serpentine venous dilatations over the entire spinal cord.

A laminectomy exposing the seventh, eighth and ninth thoracic vertebrae was performed.

Incision of the dura revealed a thick vermiform varix about 5 mm. in diameter on the dorsal aspect of the cord extending cephalad and caudad beyond the limit of the operative field. The varix was bluish red, and as far as could be ascertained did not appear to be thrombosed at this particular site. The lesion was considered inoperable and the wound was closed in layers.

Following operation the patient was in continual severe pain. He died suddenly about two weeks later. Autopsy permission could not be obtained.

COMMENT

From a clinical point of view, the variation in the symptoms with exacerbations and marked remissions may be significant for this type of lesion since it probably indicates variations in the degree of vascular dilatation in the lesion. Another very important point is the considerable increase in total protein in the cerebrospinal fluid (120 mg. per 100 cc.) in the absence of a manometric block. This would suggest that transudation may occur through the thin-walled blood vessels which comprise the lesion.

We believe, as was true in our case, that the diagnosis can be made from lipiodol myelography, but that the above points in the clinical record may lead to a suspicion of the correct diagnosis before myelography is done.

REFERENCES

1. Black, W. C., and Faber, H. K. Blood vessel tumor of spinal cord in a boy aged nine years, with special reference to a new diagnostic syndrome. *J. Am. M. Ass.*, 1935, *104*, 1889–1891.
2. Buchanan, D. N., and Walker, A. E. Vascular anomalies of spinal cord in children. *Am. J. Dis. Child.*, 1941, *61*, 928–932.
3. Cabot Case. *Boston M. & S. J.*, 1927, *197*, 441. Quoted by Black and Faber.[1]
4. Globus, J. H., and Doshay, L. J. Venous dilatations and other intraspinal vessel alterations, including true angiomata, with signs and symptoms of cord compression. *Surg., Gynec. & Obst.*, 1929, *48*, 345–366.
5. Hare, C. C., and Everts, W. H. Calcified subpial lesion of the spinal cord with asscoiated varicose veins. *Bull. Neurol. Inst. New York.*, 1937, *6*, 295–299.
6. Kaydi. Quoted by Globus and Doshay.[4]
7. Kortzeborn, A. Laminektomie bei Angioma racemosum des Rückenmarkes. *Zentralbl. f. Chir.*, 1929, *56*, 868–877. Quoted by Black and Faber.[1]
8. Turner, O. A., and Kernohan, J. W. Vascular malformations and vascular tumors involving the spinal cord; pathologic study of 46 cases. *Arch. Neurol. & Psychiat.*, 1941, *46*, 444–463.

EXPERIENCES WITH ROENTGEN IRRADIATION FOLLOWING OPERATION ON BRAIN TUMORS*

By STUART N. ROWE, M.D., F.A.C.S., *and* HAROLD W. JACOX, M.D.
From the Landon Surgical Clinic and the Department of Radiation Therapy, Western Pennsylvania Hospital
PITTSBURGH, PENNSYLVANIA

THE treatment of patients suffering from gliomas of the brain is for the most part unsatisfactory and as depressing as is the treatment of rapidly growing neoplasms in other parts of the body. However, we have been impressed by the good palliative results often obtained in seemingly hopeless conditions by operation and subsequent irradiation, and have been prompted thereby to review our experience in this field. We have collected a group of cases of known cerebral gliomas (excluding pituitary neoplasms, metastatic tumors and meningiomas) and a group with strong presumptive evidence of such a lesion, with follow-up observation of at least one year of the patients who are living. The known tumors consisted of 8 glioblastomas (multiforme), 6 medulloblastomas, 5 astrocytomas, and 2 mixed gliomas. In 12 patients no tumor tissue could be obtained at operation. From the standpoint of location there was a wide diversity, essentially every area of the brain being represented with the exception of the occipital lobe. These 33 cases have not been considered adequate material for a statistical study, but we feel they indicate the trend of our clinical experience.

While it is the purpose of this paper to discuss therapy primarily, one or two remarks concerning diagnosis may be apropos. In several instances delay in establishing the diagnosis may have handicapped the treatment. The error usually resulted from the incorrect interpretation of an isolated symptom such as vomiting, generalized convulsions, or impaired vision. We have been impressed with the value of ventriculography and have employed it in two-thirds of these patients. Although its use appears to be a confession of weakness in neurological localization or diagnosis, we feel that the benefits derived are manifold. The ventriculogram permits a minimal-sized surgical exposure and to some extent indicates the depth of the lesion, and even if the tumor cannot be reached at operation the films provide a reasonable basis for diagnosis and localization. This last point may be very vital in deciding upon the use of radiation therapy and choice of fields if it is used. We have found postoperative ventriculograms much more difficult to carry out adequately and to interpret.

In the cases of verified tumor only one gross error of localization was made—the rather classic one of mistaking a tumor close to the third ventricle for a lesion in the posterior fossa. Fortunately, this patient survived the negative cerebellar exploration as well as a later ventriculogram and correctly placed surgical attack (see Case III).

The effects of operation alone were difficult to determine. The time interval between the surgery and irradiation was usually short—varying from ten days to two months with an average of three weeks—thus permitting estimation of immediate results only. On this basis, as far as could be judged, about half the patients were definitely benefited by surgical removal of the tumor or by decompression. Doubtless in an additional group some of the later improvement was related to operation as well as to irradiation, a point which will be considered below.

* Read before the American Academy of Neurological Surgery, San Francisco, California, Nov. 15, 1941, and the Pittsburgh Surgical Society, Jan. 16, 1942.

The technique of the roentgen therapy was not marked by startling innovations. Instead of adopting any fixed numerical maximum exposure, we aimed to irradiate each patient to the limit of his tolerance. Treatment with high voltage roentgen rays (200 kv. and 0.5 mm. copper filtration) was begun slowly in an effort to minimize the reaction—particularly elevation of intracranial pressure—but if the patient's general condition and the tolerance of the scalp would permit, rather large total amounts were given (up to 3,400 r, measured in air, to one portal and totals of 7,700 r divided among four portals). Usually exposures of 100 to 200 r were given daily except Sunday, for approximately three weeks. Subsequent series were administered chiefly when the beginning of a clinical decline indicated their need (unless the condition of the scalp demanded further delay), the shortest interval between series being four weeks. We have not used radiation therapy through the open wound.

Obviously numerous factors affect the results of roentgen treatment (location of the tumor, size of the tumor, age and general condition of the patient, etc.), but certainly the pathologic type of neoplasm is of primary importance.

The glioblastoma multiforme (or spongioblastoma multiforme) is perhaps the most discouraging type of cerebral tumor. Frequently the lesion is far advanced when seen by the neurosurgeon, usually its depth and extent make complete removal impossible, and even after block resection its tendency to recur is notorious. Here would seem to be an ideal field for roentgen therapy. However, we have encountered two difficulties: First, a number of our patients were so ill that the burden of large amounts of roentgen radiation could not be added. Even with preliminary decompression or partial removal, adequate therapy could not be tolerated by the patient and the general down-hill course could not be halted. In another group the tumor was apparently unaffected by irradiation and continued its rapid growth. In approximately half our patients the results were hampered by one or the other of these factors. In the remaining cases, particularly when most of the tumor could be removed and extensive irradiation tolerated, worthwhile prolongation of the patient's confortable and useful life occurred. Such a result is illustrated by the following case:

CASE 1. L. M., white male, aged forty-five, was well until two years before admission when he suddenly experienced a fainting spell, followed by severe headache. A year before entrance the same thing happened again and this was followed by nausea and vomiting and occasional headaches. The headaches gradually became more severe and in the last nine months were localized to the left temporal region.

The patient was first studied by one of us (S.N.R.) in the Veterans' Administration Facility, Aspinwall, Pennsylvania, where the clinical picture was suggestive of an intracranial aneurysm with repeated subarachnoid hemorrhage.

When he was seen two months later neurological examination showed choked discs of about two diopters, complete loss of the temporal visual field on the right and slight cutting of the nasal field of the left eye, and a marked mixed aphasia. Ventriculograms disclosed a shift of the entire ventricular system to the right, and a defect in the temporal and parietal portions of the left lateral ventricle.

At operation (November 2, 1940) a large, infiltrating, partly necrotic tumor was almost totally removed from the posterior portion of the left temporal and anterior part of the left parietal lobes. Microscopic section showed a typical glioblastoma multiforme.

Eleven days postoperatively the patient received the first of a series of high voltage roentgen treatments to two portals, cross-firing the left temporoparietal region. Each portal received 2,100 r (measured in air) within a period of eighteen days at the rate of 200 r per day.

The patient made a steady recovery with complete disappearance of all symptoms and more than one year after operation remains in good condition. He has been working full time for the past six months.

Medulloblastomas are generally considered to be the most radiosensitive of the

gliomas,—indeed a preliminary trial of roentgen therapy has been advocated for clinically suspected tumors of this type. Fearing the development of fatal medullary compression we have not used such preoperative treatment. Despite their radiosensitivity the clinical response to irradiation was less than we anticipated in our series. The failures seem to result either from a tendency of the tumor to become radioresistant or the development of cord metastases which recurred in spite of intensive therapy. It may be argued that the latter difficulty ensues because the operative attack leads to seeding of the tumor down the spinal canal but in one instance in this series spinal metastasis occurred before operation. The following case is representative of our experience:

Case II. A. Z., male, aged seventeen, referred by Dr. S. B. Meyers, of Johnstown, Pennsylvania, had been troubled for about one year by dizziness upon bending over. Five months before entrance left-sided tinnitus, headaches and pain in the back of the neck followed by nausea and vomiting developed. These symptoms became steadily worse until admission.

Examination revealed only very slight bilateral signs of cerebellar dysfunction and bilateral papilledema of four dipoters. Routine roentgen examination of the skull showed prominent convolutional markings in the frontal and parietal regions, but no other abnormalities. Ventriculograms demonstrated enormous dilatation of the lateral and third ventricles with obstruction of the lower end of the aqueduct.

The usual suboccipital craniectomy revealed a soft reddish tumor in the left cerebellar hemisphere which also infiltrated the vermis and the floor of the fourth ventricle. Only a small portion of the tumor was removed for biopsy, the pathologic report being "protoplasmic astrocytoma."

Beginning ten days postoperatively the patient received 3,000 r (measured in air) in twenty days to a field 8 by 10 cm. in size directly over the cervico-occipital region, given at the rate of 100 to 200 r per day. He made an excellent recovery and was normal except for slightly impaired vision for three months when he returned complaining of numbness of the right leg and left chest, suggesting spinal cord involvement. During this admission 1,400 r to each of three long narrow portals over the entire spine was given and the symptoms disappeared. He returned in four months with signs and symptoms of cerebellar recurrence and 2,500 r was given to the suboccipital region and 600 r to each of three portals over the spine. The patient showed only slight response, however, and died two and one-half years from the date of onset or one and one-half years from the beginning of treatment.

In retrospect it is possible to see several defects in the handling of this patient. The biopsy was somewhat traumatized—which contributed to the erroneous pathologic diagnosis. Furthermore, when the spinal metastasis indicated the correct diagnosis of medulloblastoma, therapy was not given over the cerebrum. Although no clinical evidence of such a lesion existed, it is barely possible that intraventricular metastases may have been present. Nevertheless, the local recurrence of the tumor despite previous heavy irradiation emphasizes the terminal radioresistance of this tumor.

It is generally agreed that astrocytomas grow slowly, are radioresistant, and occasionally are amenable to complete surgical extirpation. On the basis of these beliefs irradiation is used relatively infrequently in combatting such tumors and our experience is limited to 5 patients, who for varying reasons received therapy. Two of these appeared to be benefited, and a summary of the record of one may be of interest.

Case III. P. G., female, aged six, one of a set of twins, referred by Dr. M. H. Weinberg, was in good health until September 1, 1939, when she began to have intermittent projectile vomiting, unsteadiness of gait and balance, impaired vision and urinary incontinence. These symptoms progressed during the four months before her admission. Examination showed the classical signs of a cerebellar tumor of the left hemisphere with no evidence of brain stem involvement.

Ventricular estimation indicated an internal hydrocephalus. Operation (January 4, 1940)

using a cerebellar approach did not reveal the tumor. Subsequently a ventriculogram disclosed a defect in the third ventricle. Through a right transfrontal approach (January 12, 1940) approximately one-third of an infiltrating tumor near the anterior part of the third ventricle was removed. Microscopically the tumor was an astrocytoma.

The patient had a very stormy and slow convalescence and remained in a state of decerebrate rigidity for weeks. Nevertheless, high voltage roentgen therapy was started seventeen days after the second operation and a total of 1,800 r (measured in air) was given to an anterior frontal and to a right and left temporal portal in twenty days. The child began to improve slowly and a year later was essentially symptom-free with the exception of a slight left hemiparesis, impaired vision, and occasional petit mal attacks. Because of the epilepsy 1,800 r was given to each of three portals exactly as before. Again improvement occurred and has been maintained for two years since the first operation.

Obviously this is a slowly growing neoplasm; however, it reached a point of producing nearly complete blindness and high intracranial pressure four months after symptoms began, whereas the child's present condition is reasonably good two years after treatment was instituted.

An unusual instance of a mixed glioma is worthy of mention. Definite evidence of extensive necrosis of the tumor and great decrease in the vascularity of the overlying tissues were found at operation following irradiation.



Fig. 1. Case iv. Roentgenogram of skull showing right frontal bone destruction, intracerebral calcification, erosion and enlargement of the sella turcica. The tumor proved to be a large mixed glioma.

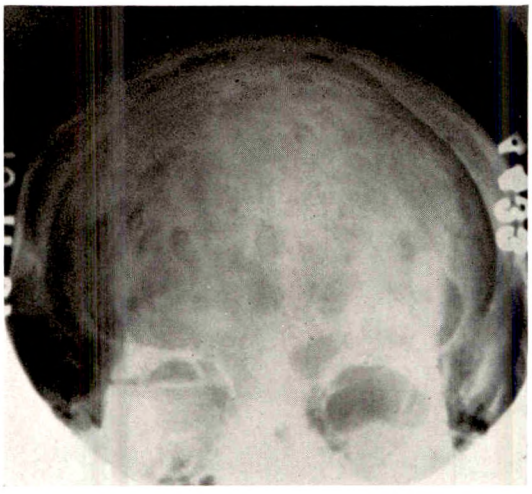


Fig. 2. Case iv. Posteroanterior projection showing peculiar bone destruction in the right frontal region and increased density in the right orbital cavity.

Case iv. M. C., male, aged thirty-three, laborer, referred by Dr. R. B. Meyers, of Johnstown, Pennsylvania, noticed flashes streaking across his field of vision in November, 1936. He also had involuntary shaking of his right leg and foot. Four months later his vision began to dim gradually and this progressed almost to blindness in five months. A month before hospitalization the right eye began to protrude.

Upon admission in October, 1937, the most striking finding was the marked proptosis of the right eye. There were also clonic contractions of the right lower extremity. Roentgen examination of the skull showed erosion of the posterior clinoid processes and floor of the sella. There were small, irregular areas of bone destruction in the right frontal, parietal, and occipital regions, increased density in the right orbit, and right frontal calcification (Fig. 1 and 2). On October 20, 1937, a right subtemporal decompression was performed. Biopsy of the bone (November 11, 1937) adjoining one of the right frontal defects showed nothing abnormal. At both operations extreme vascularity of all tissues was noted.

Beginning one month postoperatively he received a total of 1,200 r to each of three portals in twelve days, cross-firing the anterior half of the skull. There was definite improvement in

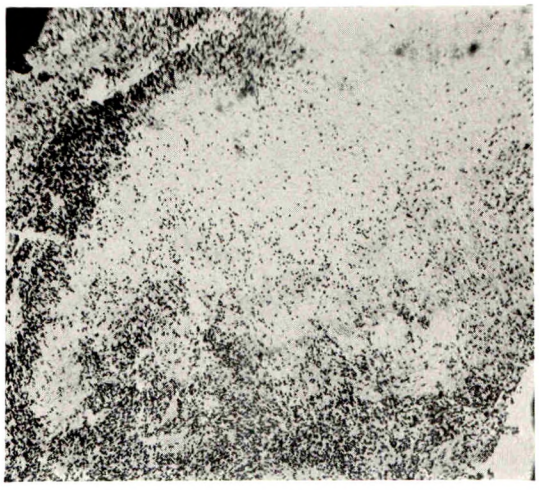


Fig. 3. Case IV. Photomicrograph of mixed glioma following irradiation. The border of a large area of necrosis is seen in this field. Hematoxylin and eosin stain; low power.

the proptosis and later 1,800 r was given to each of the same three areas in thirty-one days. Again there was improvement, but the patient developed a cerebrospinal rhinorrhea.

On November 25, 1938 a right transfrontal craniotomy was performed and a degenerated, necrotic tumor 6 or 7 cm. in diameter, occupying the greater part of the right anterior cranial fossa, was removed. Microscopically this proved to be an interesting mixed glioma, for the most part resembling astrocytoma but showing areas of definite glioblastoma multiforme (Fig. 3). This type of tumor has recently been discussed by Munro, Edwards and Russell.[3]

Ten days postoperatively a third series of roentgen treatments consisting of 1,700 r to each of four portals was given in nineteen days. Again he was improved for about six months when the proptosis became worse and the vision almost nil. A final course of 2,700 r was given to one large anterior frontal portal in ten days. He was fairly comfortable up to his death at home three years and four months after the onset of symptoms and nearly two and one-half years after the first hospitalization.

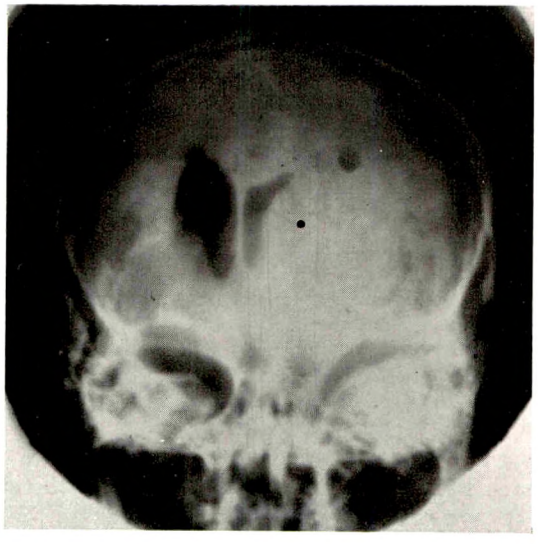


Fig. 4. Case V. Ventriculogram showing displacement of the entire ventricular system to the right and dilatation of the right lateral ventricle.

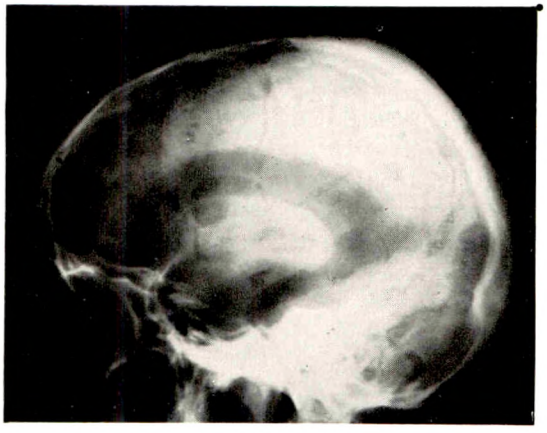


Fig. 5. Case V. In the lateral ventriculogram the dilated right lateral ventricle and the absence of filling of the parietotemporal portions of the left lateral ventricle are illustrated.

There remains the group of patients in whom no tumor tissue was obtained at operation. Should one irradiate the unverified tumor? Certainly the decision must be made in each case on its own merits. Where there is a gross error of diagnosis or localization, the mistake usually becomes apparent soon after the surgical attack and obviously irradiation should not be undertaken. But when the failure of verification is due to the deep situation of the tumor and strong clinical and ventriculographic evidence of its presence are at hand, roentgen therapy has proved very helpful in our experience. In more than half of our group of 12 cases of this type marked clinical improvement

has been obtained. One very striking example indicates the problems involved as well as the results of therapy.

Case V. M. N., white female, aged twenty-one, referred by Dr. Martin, of Duquesne, Pennsylvania, came to the Western Pennsylvania Hospital in July, 1938, for relief of convulsions which she had had for three years. The convulsions were jacksonian in type on the right and increasing in frequency. For three months she had noticed blurring of vision in the left eye.

Neurological examination showed only bilateral papilledema and slight reduction of visual acuity. The patient had a linear area of left frontal scleroderma (of long standing) which extended across the forehead to the nose.

Routine roentgenograms of the skull showed evidence of considerable increase in intracranial pressure. Ventriculograms showed moderate enlargement of the right lateral ventricle and a shift of both lateral ventricles and the third ventricle to the right (Fig. 4 and 5).

At a left parietotemporal craniotomy on August 2, 1938, the brain was under great pressure, and no tumor could be seen or reached with a brain cannula. Nine days later a second attempt was made through an incision in the left temporal lobe but no neoplasm was found.

Two months later the decompression was bulging and a series of high voltage roentgen treatments was given over both sides of the head. Two thousand roentgens (measured in air) was given to each temporoparietal portal in fifteen days. The bulging disappeared two months after completion of the treatments and the patient became almost entirely normal.

Seventeen months later the patient developed aphasia, weakness and tremors of the right upper extremity and occasional short attacks of unconsciousness. Fifteen hundred roentgens was applied to three smaller portals, but otherwise exactly as before.

During the first month after the second series of treatments the patient suffered one jacksonian attack accompanied by aphasia and pain in the left parietal region. Another ventriculographic study showed the left lateral ventricle obstructed and pushed upward and outward in its posterior third. The third ventricle could not be seen. A third left parietotemporal craniotomy failed to reveal the tumor, though a transcortical incision was carried to a depth of 5 cm.

When seen six months after the second series of roentgen treatments the patient was in fair condition and was troubled only by moderate motor aphasia. At present she lives at her parents' home where she does much of the housework. She has had brain tumor symptoms for a total of six years, and has been under treatment over three years.

DISCUSSION

What proof is there that high voltage irradiation has any effect on most gliomas? The natural tendency is to attempt to answer the question on the basis of histologic sections before and after irradiation. It is obviously difficult to obtain tissue for post-irradiation examination in many cases. Furthermore there are several possible sources of error in this method: (1) changes in a tumor which are presumably the result of roentgen irradiation can be demonstrated histopathologically when the patient has shown little if any corresponding clinical improvement; (2) all the histologic changes which iradiation produces within a glioma may also occur spontaneously; (3) varying areas within the same tumor may present widely different histopathologic pictures. The shortcomings of this method have been recognized by others.[1,2,4]

The only other way of evaluating the results of roentgen irradiation is on the basis of the clinical course. This, too, has its pitfalls. It is difficult to separate the effects of operation from the effects of irradiation, or vice versa. Although a fairly accurate standard of life expectancy for a given type of glioma has been set up, it is practically impossible to predict the natural course of the disease for a given patient, in whom the duration, extent and location of the lesion cannot be sharply defined.

Nevertheless, we feel that in some cases it is possible to demonstrate clear-cut evidence of clinical improvement due to irradiation and believe that if reasonable caution is exercised, this method offers a satisfactory means of evaluating the therapy. Occasionally a false impression of the effectiveness of therapy might be

given by a slowly growing type of tumor. Because of this we have emphasized the preoperative duration of symptoms in discussing the postoperative and post-irradiation result in each case. Again late improvement may sometimes be the result of surgical treatment rather than of roentgen therapy. However, in several patients the response to operation was so slight and improvement following roentgen irradiation so definite that there could be little question of the effectiveness of the latter. In addition, a number of patients showed a definite response to irradiation at a stage when their gain from previous surgical or roentgen therapy was rapidly waning. Cases III and V illustrate this point very well.

In conclusion, we do not wish to leave the impression from the discussion or illustrative cases that we regard roentgen therapy as a panacea in the management of gliomas. As has already been stated, approximately half our cases followed a rapid down-hill course. However, the number of patients in the remaining group who obtained substantial prolongation of useful life as a result of operation and irradiation seems to justify the continued use of these methods even in cases of an apparently hopeless character.

Doubtless the accumulation of additional clinical and pathologic studies will eventually enable more accurate prognosis as to the results of roentgen therapy in gliomas, or lead to discovery of other more effective methods of treatment.

SUMMARY

1. The best results of combined surgical and roentgen therapy seem to be obtained when most of the tumor can be removed and intensive irradiation given without dangerously increasing the intracranial pressure.

2. There are frequent exceptions to the usually accepted rules as to the radiosensitivity of various types of glioma.

3. In dealing with brain tumors which are inaccessible surgically, decompression and irradiation may occasionally produce prolonged benefit.

4. Approximately half the patients in this series died within one year regardless of surgical or roentgen treatment. However, at the present time it is impossible to determine before treatment is begun which patients will fall into this hopeless group and which may be definitely benefited by treatment.

5. We believe that one is rarely justified in refusing operation or roentgen therapy or both even to the patient who presumably has an advanced, highly malignant, or deeply situated brain tumor.

REFERENCES

1. Deery, E. M. Remarks on effects of roentgen therapy upon gliomas. *Bull. Neurol. Inst. New York*, 1936, *4*, 572–587.
2. Frazier, C. H., and Alpers, B. J. Effect of irradiation on gliomas. Association for Research in Nervous and Mental Disease, 1935, *16*, 68–106.
3. Munro, D., Edwards, J. E., and Russell, W. O. Mixed intracranial gliomas; diagnostic and prognostic significance of adequate histological examination. *Surg., Gynec. & Obst.*, 1941, *72*, 787–797.
4. Voris, H. C. Evaluation of irradiation in management of brain tumors. *Internat. Abstr. Surg.*, 1940, *71*, 307–313. In *Surg., Gynec. & Obst.*, Oct. 1940.

tained from the applications of radium and the local cleansing procedures employed, and the like. The radium technique we employ may be referred to as a broken-dose, intensive method. The filters, treatment time, distribution of the dose throughout the involved area, and the time interval between treatments are so selected as to meet the individual requirements of the patient. At the end of a complete course of radium therapy, which usually requires about three weeks for a patient with a Stage III cancer of the uterine cervix, a supplemental course of roentgen therapy is administered. A follow-up examination carried out every three months for the first year is recommended. We have found the method[3] very satisfactory in that it allows a very wide range of individualization.

From 1915 to 1929, inclusive, we found that 8.7 per cent of the patients referred for radium therapy had lesions of Stage I and Stage II, and that 91.3 per cent had lesions of Stages III and IV based on the League of Nations classification.[5]

Our five year "cures" obtained with radium treatment and supplementary roentgen therapy, based on 1,491 patients,[2] according to stage, were as follows: Stage I, 69.2 per cent; Stage II, 60.2 per cent; Stage III, 29.7 per cent and Stage IV, 6.5 per cent.

Surgical operation is confined in selected cases to lesions of Stages I and II. The rate for five year "cure" of cancer of the cervix by total abdominal hysterectomy with irradiation, based on 165 patients seen from 1910 to 1938, inclusive, was 57.1 per cent of the traced patients.[7]

In this study we considered surgical methods as constituting a rather standardized procedure. Excellent radical operative procedures have been evolved which are employed by skilled surgeons everywhere. As Masson[7] has said, "The type of surgical procedure indicated for carcinoma of the uterus will probably never be improved."

Next in importance to the stage or extent of the lesion is the microscopic grade of the cancer, which has been recognized to be in the main of surgical prognostic importance in that patients who have a low grade lesion do well, whereas patients who have a high grade lesion do poorly, after surgical intervention. In our own experience, of patients referred for radium therapy of cancer of the cervix, only 16 per cent had lesions of Grades 1 and 2, and 84 per cent had lesions of Grades 3 and 4.

TABLE III

RESULTS OF RADIATION THERAPY FOR CARCINOMA OF THE UTERINE CERVIX, BASED ON THE GRADE OF MALIGNANT CHANGE

Lesion, Grade	Patients			
	Treated	Traced	Lived 5 years or more after treatment	
			Number	Per cent*
1	5	5	2	40.0
2	135	122	40	32.8
3	407	362	125	34.5
4	336	307	105	34.2
Total	883	796†	272	34.2

* Percentage of traced patients.
† 90.7 per cent traced; total, 1,491 patients.

With the individualized radium therapy employed, and on the basis of a survival of five years, results of treatment of carcinoma of the cervix show that lesions of Grades 3 and 4 are no more fatal than are lesions of Grades 1 and 2. Patients who had Grade 1 lesions were too few to consider, but 135 patients with Grade 2 lesions were followed, and of this number 40 patients, or 32.8 per cent, lived five or more years. There were 407 patients with Grade 3 lesions, and of these 125, or 34.5 per cent, lived five years or more. There were 336 patients with Grade 4 lesions, and of these 105, or 34.2 per cent, survived five years or more. The five year "cure" rate computed according to grade of lesion is shown in Table III.[1] It is seen that the rate is, roughly, the same in all grades, but that only 5 patients with lesions of Grade 1 were treated.

When patients treated by surgery as well as by irradiation are added (referring again to Masson's study of 1939, embracing ex-

TABLE IV

CARCINOMA OF THE CERVIX: SURGICAL AND IRRADIATION RESULTS, 1910–1939*

Malignancy, Grade	Patients Traced	Per Cent of 5 Year Cures
1	5	60.0
2	190	41.1
3	678	37.9
4	511	33.7

* Adapted from Masson.[7]

perience from 1910 to 1938), the five year survival rates computed according to grade evolve as shown in Table IV.[7] Patients who had Grade 1 lesions obtained the best results and those who had Grade 4 lesions obtained the poorest results Results are calculated on the basis of a selected group of patients and yet may show the influence of standard treatment procedures. Evidently, in cases of cancer of the uterine cervix, we lack sufficient numbers of patients in certain grade and stage groups for satisfactory studies of correlation of microscopic grade with stage, as shown in Table V. For example, there were only 10 Stage 1 cases and 5 Grade 1 cases (Table V) out of the total of 883 lesions previously recorded in Table III. There seemed, however, to be sufficient distribution of grade in Stage III lesions for correlation purposes; although again the Grade 1 lesions are too few for purposes of such a consideration (Table V). For correlation determinations we selected Stage III lesions of Grades 2, 3 and 4 from Table V for computation of survival rates of five or more years, and again the survival rate in each grade in this group rather equal: 35.0, 34.1 and 35.1 per cent, respectively (Table VI). We submit that these data, based on a limited number of cases, probably indicate the influence of a tedious individualized radium therapy technique, designed to meet the requirements

TABLE V

CARCINOMA OF THE UTERINE CERVIX TREATED BY IRRADIATION ALONE, 1915–1929 DISTRIBUTION ACCORDING TO STAGE AND GRADE OF MALIGNANCY

Stage	Grade				Total
	1	2	3	4	
I	—	—	7	3	10
II	1	11	30	28	70
III	4	109	322	254	689
IV	—	15	48	51	114
Total	5	135	407	336	883

TABLE VI

CARCINOMA OF THE UTERINE CERVIX TREATED BY IRRADIATION ALONE: FIVE YEAR SURVIVAL RATES ACCORDING TO STAGE AND GRADE, 1915–1929

Stage of Lesion	Microscopic Grade of Lesion (Broders' Index)											
	2				3				4			
	Patients				Patients				Patients			
	Total	Traced	Alive 5 years or more after treatment		Total	Traced	Alive 5 years or more after treatment		Total	Traced	Alive 5 years or more after treatment	
			Number	Per cent*			Number	Per cent*			Number	Per cent*
III	109	100	35	35.0	322	287	98	34.1	254	231	81	35.1
IV	—	—	—	—	48	41	3	7.3	51	47	4	8.5

* Of traced patients.

of the patient being treated, on the results to be obtained.

CANCER OF THE UTERINE FUNDUS

Cancer of the uterine fundus presents a great irradiation therapeutic problem. It is considered to be a less malignant neoplasm than cancer of the cervix; the rate of growth appears to be slower and the tendency to metastasize develops later.

If the diagnosis can be established while the lesion still appears to be confined within the mucosa of the uterine walls, a less radical operation than is required for cancer of the cervix, and generally accomplished with less risk, usually is curative. However, when the disease is advanced and has infiltrated surrounding tissues or metastasized to other organs, worth-while palliation or even cure can be secured by radiation therapy alone.

Cancer of the uterine fundus is a hidden lesion, not accessible to inspection and less revealing on palpation than is cancer of the uterine cervix, so that the stage of the lesion is more difficult to evaluate. The diagnosis must always be established by study of the tissue obtained by curettage. The stage or extent can be determined only by the results of pelvic, general and special examinations. We have classified the lesion into four stages to correspond to the classic four stages of cancer of the cervix. Briefly, in Stage I the neoplasm apparently is superficial, the uterus is normal in size and is freely movable. In Stage II, the lesion has increased and involves the muscular wall; the uterus may be enlarged, although it is still movable. In Stage III is revealed extension beyond the uterine walls to neighboring tissues, with beginning fixation. In Stage IV, "frozen pelvis" has occurred, often with involvement of the bladder or rectum, or both, or a small primary lesion has metastasized to distant organs.

Results of surgical and radiation therapy vary according to the stage or extent, and also the microscopic grade, of the lesion. As Sackett[8] has reported, panhysterectomy with supportive irradiation accomplishes a five year cure in from 55 to 75 per cent of cases in this country; radiation therapy alone, in cases in which the disease is more extensive (precluding surgery) achieves a five year survival for from 25 to 50 per cent of the patients treated.

TABLE VII

CARCINOMA OF THE UTERINE FUNDUS: SURVIVAL RATES ACCORDING TO OPERATION AND IRRADIATION, 1910–1938*

Treatment	Treated	Died in Hospital, Per Cent	Traced	"Cured" 5 Years, Per Cent
Total abdominal hysterectomy with irradiation	194	1.0	191	67.5
Total abdominal hysterectomy without irradiation	306	8.5	296	66.6
Irradiation without hysterectomy	230	0.9	227	26.9

* Adapted from Masson.[7]

Masson,[7] in reviewing data concerning patients treated from 1910 to 1938, inclusive, at the Mayo Clinic, showed that in respect to five year survival rates total abdominal hysterectomy with and without irradiation yielded almost similar results: 67.5 per cent and 66.6 per cent, respectively (Table VII).

In later years, more amenable lesions have been treated by irradiation in preference to surgery. Better diagnostic methods have revealed lesions in earlier chronologic stages. But, since cancer of the uterine fundus is mainly a postmenopausal condition which afflicts women of a later age group, many unrelated degenerative diseases often complicate the picture and increase the operative risk. In a later review of patients treated by radium alone from 1925 to 1935, inclusive, our five year sur-

vival rate was seen to have increased to 39 per cent.[4] Practically a third of all patients seen at the Mayo Clinic with carcinoma of the uterine fundus have been referred for irradiation alone at this particular age period because of the extent of the lesion and the presence of associated degenerative diseases. Our five year survival rate has been influenced by the stage of the lesion,

TABLE VIII

CARCINOMA OF THE UTERINE FUNDUS: RESULTS WITH RADIUM THERAPY

Lesion, Stage	Patients Traced	Five Year Cures, Per Cent
I	15	93.0
II	29	52.0
III	32	34.0
IV	33	6.0

as is shown in Table VIII. The best results were obtained for those who had Stage I lesions; for them the five year survival rate was 93 per cent. The poorest results were obtained for those who had Stage IV lesions; for them the five year survival rate was only 6 per cent.

Results of this study showed clearly that determination of stage or extent of the neoplasm before treatment, although much more difficult in these cases, was accurate for prognostic purposes. Radium treatment was not individualized, but consisted of what may be considered standardized general irradiation along the entire length of the uterine canal achieved by tandems and single radium tubes, the number of tandems employed depending on the depth of the uterine cavity.

TABLE IX

CARCINOMA OF THE UTERINE FUNDUS TREATED WITH RADIUM

Grade	Patients Traced	Per Cent of 5 Year Cures
1	19	79.0
2	42	33.0
3	16	25.0
4	17	12.0
Not graded	15	47.0
Total	109	39.0

Results computed according to the microscopic grade of the lesion were surprising, from the standpoint of the radium therapist. Whereas, in cancer of the uterine cervix a lesion of Grade 4 was no more fatal than a lesion of Grade 2 (Table VI), high grade carcinomas of the uterine fundus were definitely more dangerous. Patients who had low grade cancer, considered by many as "radioresistant," did very well (Table IX).

SUMMARY

Brilliant improvement in surgical technique has developed the radical operations for cancer of the uterine fundus and for early cancer of the cervix to a high degree of efficiency. Results in well selected cases are excellent, and the operative procedures have become standardized in the hands of leading surgeons everywhere. The value of the present surgical technique has been proved and it is likely that no changes in the surgical approach will ensue.

In this study no new data have been presented, but we are submitting a conception or perhaps a "philosophy of treatment," which we have held for a long time. It seems very evident that to careful radium therapists the treatment of cancer of the uterine cervix is an individualized scheme. Not only do different clinics have varying methods of treatment, but the same radiologist will alter his method of attack on different lesions, because the lesions vary greatly and also because the rate of response to treatment probably differs with the amount of defensive factors of the patient's tissues against cancer. It is well known that radium can be used as cautery, or, if differently applied, will exert not a caustic but a healing effect, to which the reactions of the normal tissue greatly contribute. The latter effect is the most desirable in that it maintains to the highest degree possible the normal integrity of the

tissues in and near the involved malignant field.

Cancer of the uterine fundus presents the problem of a hidden lesion which is inaccessible to accurate estimation of its extent. Herein, to date, radium treatment has been rather standardized, consisting of homogeneous irradiation along the entire length of the uterine canal. Even though the percentage of "cures" or "arrests" secured with radium treatment alone has been encouraging, radiologists have put forth every effort to individualize the treatment. Heyman's multiple tube technique, the Schmitz Y-shaped applicator and the Friedman hysterostat are specific instances of this effort. This is encouraging, although in view of the nature of carcinoma of the uterine fundus these efforts will probably always be limited.

Radium treatment of cancer of the uterine fundus yields encouraging results, and in the course of time further advances in technique may succeed in creating a more flexible, less standardized program of treatment and may produce even superior results, comparable to those achieved by radium therapy in cancer of the uterine cervix.

CONCLUSIONS

1. The extent of the primary malignant lesion of the uterus is the most valuable prognostic factor.

2. The grade of malignant change (Broders' index) is a very valuable prognostic determination when more standardized surgical and radium therapeutic techniques are employed. This observation does not seem to be entirely true when individualized radium therapy is employed in cancer of the uterine cervix.

3. Evidently, the most individualized radium therapy designed to meet the demands of the patient under treatment for cancer of the uterus will give the best result.*

REFERENCES

1. BOWING, H. H. Carcinoma of the cervix uteri; factors influencing prognosis. *Minnesota Med.*, 1940, *23*, 85–93.
2. BOWING, H. H., and FRICKE, R. E. Carcinoma of the uterine cervix; survey of treatment and results in 1,491 cases. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 47–51.
3. BOWING, H. H., and FRICKE, R. E. Radiosensitivity of malignant neoplasms of the uterine cervix. *J. Am. M. Ass.*, 1938, *111*, 1902–1907.
4. FRICKE, R. E., and BOWING, H. H. Further studies in the radium treatment of carcinoma of the uterine fundus. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 683–688.
5. League of Nations, Health Organization, Cancer Commission: Report submitted by the Radiological Sub-Commission. Geneva, League of Nations Publications, 1929, 82 pp.
6. LENZ, MAURICE, STENSTROM, WILHELM, and SANTE, L. R. Report of the Standardization Committee of the American Radium Society on the methods used and results obtained by members of the Society in radiotherapy of cancer of the uterine cervix. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 376–380.
7. MASSON, J. C. Carcinoma of the uterus. *New Orleans M. & S. J.*, 1939, *92*, 235–244.
8. SACKETT, N. B. Surgical treatment of cancer of the corpus uteri. In Pack, G. T., and Livingston, E. M.: Treatment of Cancer and Allied Diseases. Paul B. Hoeber, Inc., New York, 1940, vol. 2, pp. 1648–1666.

* For discussion see page 515.

THE ELIMINATION OF IRRADIATION INJURIES IN THE TREATMENT OF CANCER OF THE CERVIX*

By CHARLES L. MARTIN, E.E., M.D., F.A.C.R.
DALLAS, TEXAS

RADIUM has been used successfully in the treatment of cancer of the cervix uteri for about thirty years, and the combined use of radium and roentgen radiation became popular a little more than twenty-five years ago. A variety of practical radium techniques was perfected early but when it was found that the more distant extensions of the disease could not be controlled with radium applied by the vaginal route, the evolution of a series of ingenious plans for increasing the irradiation effect of the periphery of the pelvis began. The advent of each new more powerful source of external irradiation has stimulated a renewed attack on the problem, and rightly so, since the total survival rate in large groups of unselected cases is still disappointing. This paper is written with no thought of discouraging those who are striving to perfect methods of treatment, but rather in an effort to stress the importance of the increased morbidity which has accompanied many of the new procedures. The tolerance of the normal structures always has been, and always will be, the limiting factor governing the use of radiant energy in the pelvis and it seems evident, as Miller and Folsome[17] have pointed out, that the most acceptable technique of the future will be the one which produces the largest number of good results with the lowest morbidity.

Our interest in this subject dates back to 1922, when several severe rectal reactions were observed following the use of vaginal radium. Soon afterwards, with the assistance of Dr. Fred T. Rogers, a series of observations was carried out on the effect of various doses of roentgen rays applied directly to exposed loops of small intestine in dogs. Unfortunately, no ionization measurements could be made at that time, and the changes in the dog's skin were used as a dosage indicator. This was not very satisfactory because the dog erythema dose was found to be much larger than the human erythema dose, but a series of changes closely paralleling those seen in treated patients were produced.

In 1923 it was shown[12] that the threshold erythema dose for the dog produced contraction of the wall of the intestine with a complete destruction of the mucosa, while the human erythema dose, as it was used clinically at that time, produced no visible changes in the intestine. Since the low voltage apparatus used for these experiments was discarded long ago, it is impossible to express the doses used in terms of roentgens, but by indirect computation it has been estimated that the dog erythema dose used in this work lies between 3 and 4 human T.E.D. If these figures be correct, this early work indicates that irreparable damage of the dog's intestine is produced by the administration of such a dose given continuously over a short period of time. Physical data indicate that the human rectum is capable of withstanding larger total doses with the accepted plans of therapy but no accurate measure of rectal tolerance under such conditions is available to me.

In 1924 an attempt[13] was made to study the end stages of the reaction produced by the application of the dog erythema dose to a single loop of intestine. In some instances the dogs developed a cachexia, accompanied by a severe diarrhea, from which they succumbed in about two months. In other instances they recovered from the primary reaction, but died in five or six months from obstruction, produced by a marked fibrosis and contracture of the irradiated segment.

* Presented at the Twenty-seventh Annual Meeting, American Radium Society, Atlantic City, N. J., June 8–9, 1942.

Patients having similar changes in the rectum following radium applications to the cervix were described by Benthin[2] in 1923, and Jeanneney and Wangermez[10] in 1929, and in 1930 Buie and Malmgren[3] reported 65 such cases observed at the Mayo Clinic. It is interesting to note that these latter authors stated that rectal damage following radium therapy was a justifiable complication. In 1932 Pemberton[18] described 7 rectal strictures, 3 sigmoid lesions and 1 case of ulceration of the ileum, and in 1935 Jones[11] reported 8 cases of stricture of the sigmoid and ileum severe enough to produce obstruction. In a personal communication he states that he has observed 10 additional cases since his paper was published.

Some have contended that the use of a prolonged divided dose roentgen-ray technique accounts for many of the rectal complications, but Healy and Frazell[8] found 9 rectal strictures in a group of 551 patients treated before the prolonged roentgen-ray procedure was adopted at the Memorial Hospital. Todd,[23] in reporting a series of almost 50 cases of intestinal damage in 1938, called attention to extensive extrinsic lesions observed in recent years. He attributed these changes to blood vessel damage resulting from irradiation of large fields with roentgen rays.

Although irradiation techniques have been much improved, and many protective devices are now in use, intestinal damage is still produced when vigorous attempts are made to cure advanced cases of cancer of the uterus. White[25] reported 7 such cases in 1940, and Wirth, Cantril and Buschke[26] observed 6 severe lesions in patients treated with supervoltage roentgen-ray equipment from 1935 to 1938. A very recent report by Cosbie,[6] published in 1941, covers a group of patients treated since 1936, with modern apparatus, and includes 11 cases of severe proctitis, with 12 cases of rectal ulceration with hemorrhage and stenosis. The protection of the intestinal tract requires much skill when heavy doses of roentgen rays are delivered directly into the pelvis with a vaginal cone, and Merritt, in reviewing this technique in 1941, stated that diarrhea with extreme debility was observed in certain individuals, while others developed a radiosclerosis of the sigmoid. Stone and Robinson[21] voice the opinion of many of the more competent radiologists when, in discussing the treatment of advanced carcinoma of the cervix, they state: "The consequences of excessive irradiation of the bladder and rectum must be disregarded because these structures or adjacent tissues are involved."

The mucous membranes of the bladder and ureters are very radiosensitive, but reports of serious injuries of these structures appear with relative infrequency in the literature. Schmitz[19] reported the obstruction of one ureter by a process which he designated as radiation fibrosis in 1920. A death from uremia, secondary to necrosis of the trigone and obstruction of both ureters, occurred in our own clinic in 1925, and a study of the tolerance of the ureters to radiation was started soon afterwards. In 1926[14] we were able to show that a dose of 75 milligram-hours administered by two 6.25 mg. monel steel radium needles placed on either side of the dog's ureter produced complete occlusion and hydronephrosis. However, a subsequent experiment[15] done in the same year showed that 2.5 T.E.D. applied directly to the ureter, with a heavily filtered capsule produced no damage. No information is available covering the maximum dose of heavily filtered radium which is safe for the ureters.

Ureteral stricture is a common complication in cancer of the cervix, and many radiologists believe that all such lesions in treated cases are produced by cancer. However, Everett[7] after studying the patients treated successfully with irradiation at the Howard A. Kelly Hospital in Baltimore, where high intensity radium applicators are used, concluded that approximately 50 per cent of these cases developed obstructive lesions involving the lower ureters with dilatation of the kidney pelves, but that only 15 per cent were sufficiently severe to

be of clinical importance. He also included in this report 63 cases of late irradiation ulceration of the bladder reported by Dean, Newell and Crossen, Smith and Colby, and described 6 cases observed in his own series.

Vesicovaginal and rectovaginal fistulae also often accompany cancer of the cervix when no irradiation is used, and the exact rôle of therapy in the causation of these unpleasant sequelae is difficult of estimation. Behney[1] reported an incidence of 26 per cent in treated cases and 31 per cent in untreated cases, and Smith,[20] after studying a series of 2,852 patients treated at the Memorial Hospital in New York, concluded that fistulae occurred at least twice as frequently in untreated as in irradiated cases. It is interesting to note that both of these reports cover work done prior to 1934 with techniques which were relatively conservative. Enough fistulae have been produced by the injudicious use of radium in the treatment of benign uterine lesions to make it apparent that such complications cannot always be attributed to the presence of cancer alone.

Vascular damage from irradiation has, in all probability, not received the attention that it deserves, since many of the necrotic lesions are undoubtedly preceded by an interference with blood supply. Emphasis was first placed on this complication in 1936 when Dalby, Jacox and Miller[6] described spontaneous fractures of the neck of the femur attributed to occlusion of the afferent vessels following the administration of heavy doses of roentgen rays to the pelvis. More recently Strauss and McGoldrick[22] have collected a series of 75 such cases, including 4 of their own. In most instances heavy doses of radium were used along with roentgen therapy, but a study of the treatment data indicates that this complication is likely to occur in patients receiving several prolonged series of roentgen treatments over the pelvis, particularly when lateral portals are used. Todd, in describing a condition which he calls an extrinsic lesion of the bowel, accompanied by extensive sclerosis, expresses the belief that blood vessel damage resulting from the application of heavy doses of roentgen rays to large portions of the pelvis is the causative factor.

Most cancers of the cervix contain pathogenic bacteria and a salpingitis is sometimes discovered when the patient presents herself for treatment. The manipulation of a bleeding vascular tumor of the cervix during the application of radium always carries with it the danger of dissemination of infection, and a conservative technique must be designed to minimize this danger.

TECHNIQUE

It is now evident that the radiotherapist treating cancer of the cervix is confronted with a problem which is far from simple. He must deliver a curative dose, estimated as not less than 7 T.E.D., to a structure bounded anteriorly by the bladder, posteriorly by the rectum and laterally by the ureters, all of which can be damaged by the therapeutic agent. When the disease extends outside the cervix, as it usually does, any attempt to efficiently irradiate a larger volume of tissue not only increases the hazards already mentioned, but endangers the vascular system supplying the bony structures and the pelvic viscera. The infected field in which all local manipulations must be carried out adds the danger of disseminated infection.

Since serious sequelae sometimes appear a year or more after treatment, the development of a safe technique is a slow procedure, based to a large extent on experience. In 1938 Corscaden, Kasabach and Lenz[4] made a careful study of irradiation injuries observed in their cases and published a technique which eliminated them. This was done by decreasing the intensity of irradiation and increasing the time. During the past ten years an attempt has been made in our clinic to eliminate the serious complications without lowering the total five year survival rate. Some of the technical changes may be lised as follows:

1. Use of multiple radium sources of moderate intensity for longer periods of time.
2. Frequent shifting of the positions of radium containers of the higher intensities.

3. Heavy filtration in all radium containers.
4. Distance applicators in the vagina used with large vaginal packs.
5. Removal of all presenting tumor tissues so that a smaller total radium dosage is effective.
6. Careful approximation of radium sources to malignant tissue.
7. Copious use of green soap in vaginal preparation for radium.
8. Frequent changing of vaginal packs.
9. No radon implants used and no radium needles placed near ureters.
10. Intensive roentgen therapy used only in more advanced cases.
11. Elimination of lateral portals in roentgen therapy.
12. Therapy given in one carefully planned series, and not repeated.
13. Long interval allowed to elapse between intensive roentgen therapy and radium therapy.
14. No intravaginal or perineal roentgen therapy administered.

During January, 1942, a survey was made of 149 consecutive unselected cases treated during the years 1936 to 1940 inclusive. Since untoward results almost always appear within two years, no case treated since 1940 was included. The techniques used were individualized as shown in the tables. Although roentgen therapy was usually given, the most effective part of the treatment was carried out with carefully placed radium applicators, prepared to irradiate all of the diseased tissue when possible. In the more diffuse lesions weak platinum radium needles, completely described in previous articles,[16] were used alone or in combination with platinum radium capsules having a wall thickness of 1.0 mm. Most of the radium treatments were given with capsules of various sizes containing from 6.25 to 50 mg. applied singly or in various combinations. The vaginal applications were made with London spools or specially prepared applicators, constructed so as to afford ample protection to the bladder and rectum. Needle implantations were made for a period of seven days. The average case treated with capsules received about eighty hours of irradiation, divided into three applications spaced a day apart. The total dose varied from 3,600 to 4,100 mg-hr. Capsules containing 50 mg. were left in the cervical canal for thirty hours, but the cervical and vaginal applicators contained multiple sources which were never left in one place for more than twenty-four hours. Cervical and vaginal applicators were never used on the same day.

The first radium application was always done under gas anesthesia. Before any manipulations were carried out the vagina and the tumor were washed repeatedly with copious amounts of green soap. This procedure is considered most important because serious post-irradiation infections were reduced to a minimum following its adoption. The entire field was next painted with tincture of iodine and the presenting portion of the tumor was destroyed by

TABLE I

SURVEY OF CANCER OF CERVIX MADE IN JANUARY, 1942

Year Treated	No. of Patients Treated	Known Dead	Untraced	Complications Possibly Due to Irradiation	Alive	
					Total Number	Symptom-free with No Evidence of Cancer
1936	32	4	13	2 fistulae	15—46.7%	14—43.7%
1937	27	7	11	1 fistula	9—33.3%	8—30%
1938	30	6	8	1 fistula	16—53.3%	14—46.6%
1939	32	8	6	0	18—56.2%	17—53.1%
1940	28	6	5	0	17—51.0%	12—42.8%
Total	149	31	43	4 fistulae	78—52.4%	65—43.2%

Table II

Tabulation of Cases

Case	Treatment Started	Primary Lesion	Pathology	Extension	Roentgen Rays r	Radium mg-hr.	Observed	Last Examination	Outcome
Patients treated in 1936									
1. A.D.	1- 9-36	Whole cervix; vaginal wall	Squam. II	Both ligaments	4 × 600	Capsules 3400	4 mo.	Cervix healed	Dead
2. R.E.D.	1-23-36	Face of cervix	Squam.	Both ligaments slight	4 × 520 2 × 2400	Capsules 4100	1 yr.	Cervix healed; abdominal mass	Untraced
3. A.B.	2- 4-36	Whole cervix	Squam. III	Lt. ligament slight		Needles 6048 Capsules 1000	5 yr. 10 mo.	No evidence of cancer	Alive
4. C.S.	2- 4-36	½″ ulcer	Squam. II	None	4 × 600	Capsules 3600	5 yr. 10 mo.	No evidence of cancer	Alive
5. H.Mc.	2- 8-36	Cervix; upper vagina	Squam. II	Both ligaments	3 × 600 4 × 2000	Needles 4032 Capsules 2200	1 yr.	Deep pelvic involvement	Untraced
6. E.S.D.	2-10-36	Whole cervix	Squam. IV	Both ligaments slight		Capsules 4620	5 yr. 10 mo.	No evidence of cancer	Alive
7. M.Y.	3-14-36	Whole cervix	Squam. II	None		Needles 5645 Capsules 3000	1 yr.	Deep pelvic involvement	Untraced
8. A.T.	3-16-36	Whole cervix	Squam. II	Lt. ligament	4 × 600	Capsules 3600 Needles 3224	5 mo.	Deep pelvic involvement	Untraced
9. W.S.	3-16-36	Whole cervix	Squam. II	None	4 × 600	Capsules 3550	5 yr. 9 mo.	No evidence of cancer	Alive
10. W.T.W.	3-17-36	Cervical canal	Squam. II	?Both ligaments	4 × 600	Capsules 3600	5 yr. 9 mo.	? of local recurrence	Alive
11. F.E.	3-18-36	Whole cervix	Squam. III	None	4 × 600	Capsules 3900	1 yr.	Local recurrence	Dead
12. A.G.	4- 6-36	Whole cervical stump	Squam. II	Lt. ligament	4 × 1200	Needles 4838	5 yr. 8 mo.	No evidence of cancer	Alive
13. A.G.	4-22-36	Large cervical crater	Squam. I	Rt. ligament		Needles 4032	6 mo.	No healing	Untraced
14. J.P.R.	4-22-36	½″ ulcer	Squam.	None	4 × 600	Capsules 3600	5 yr. 8 mo.	No evidence of cancer	Alive
15. R.H.	5- 4-36	Nodular cervix	Squam. II	Both ligaments	4 × 1200	Capsules 3600	2 yr. 9 mo.	Rectovag. fistula-recur.	Untraced
16. M.E.S.	7- 2-36	Post. radium recurrence	Squam.	Both ligaments	4 × 600	Capsules 2850	3 mo.	Deep pelvic extension	Untraced
17. B.H.	8- 1-36	Small nodular cervix	Squam. II	None		Needles 4550	5 yr. 4 mo.	No evidence of cancer	Alive
18. A.M.R.	8-21-36	Whole cervix; vaginal wall	Squam. II	None	4 × 600	Capsules 3100	5 yr. 4 mo.	No evidence of cancer	Alive
19. C.W.	9- 1-36	Whole cervix	Squam. II	None	3 × 560	Capsules 3600	5 yr. 3 mo.	No evidence of cancer	Alive
20. R.B.W.	9- 8-36	Cervix and upper vagina	Squam. II	Both ligaments	4 × 600 4 × 2000	Capsules 2900	6 mo.	Bladder involvement; hydronephrosis	Untraced
21. S.G.	9-14-36	Large cervical crater	Squam. II	Both ligaments	4 × 600	Capsules 2700	4 mo.	Deep pelvic extension	Untraced
22. B.B.R.	9-28-36	Whole cervix	Squam. III	Both ligaments—slight	4 × 600	Capsules 3500	2 mo.	Local improvement	Untraced
23. W.E.T.	10-19-36	Whole cervix; upper vagina	Squam. III	None	4 × 600	Capsules 3400	5 yr. 2 mo.	Vesicovag. fistula repaired; no cancer	Alive
24. M.C.	10-19-36	1″ mass vaginal wall	Adenoca. I	Bladder		Needles 4836		Did not return	Untraced
25. J.M.B.	10-20-36	Whole cervix; vaginal wall	Squam. III	None	4 × 600	Capsules 3600	6 mo.	Cervix healed—abdom. mass	Untraced
26. Z.D.	10-29-36	Whole cervix; upper vagina	Squam. II	Both ligaments—slight	4 × 600 4 × 2000	Capsules 3700	10 mo.	Deep pelvic extension	Untraced
27. B.W.	11- 2-36	Whole cervix; vaginal wall	Squam. III	None	4 × 600	Capsules 3600	5 yr. 1 mo.	No evidence of cancer	Alive
28. J.D.L.	11- 2-36	¾″ mass	Squam. II	None	4 × 600	Capsules 3700	5 yr. 1 mo.	No evidence of cancer	Alive
29. C.S.B.	11-17-36	Whole cervix	Squam. II	Both ligaments	6 × 2000	Needles 5640 Capsules 1650	1 yr. 9 mo.	Deep pelvic extension	Dead
30. J.C.D.	11-19-36	¾″ mass cervical stump	Squam. III	None	4 × 600	Capsules 2300	5 yr. 1 mo.	No evidence of cancer	Alive
31. G.B.	11-30-36	Whole cervix	Squam. II	None	4 × 600	Capsules 4600	9 mo.	No evidence of cancer	Died of pneumonia
32. J.S.P.	11-30-36	1″ mass	Squam. II	None	4 × 600	Capsules 3600	5 yr. 1 mo.	No evidence of cancer	Alive
Patients treated in 1937									
1. W.C.K.	1-25-37	Mass filling upper vagina	Squam. III	Both ligaments	4 × 600	Capsules 4000	2 mo.	No healing	Untraced
2. S.H.	2- 4-37	½ cervix; vaginal wall	Squam. IV	None	4 × 600	Capsules 3600	4 yr. 10 mo.	No evidence of cancer	Alive
3. R.C.	2- 6-37	1″ mass	Squam. III	None	4 × 600	Capsules 3800	4 yr. 10 mo.	No evidence of cancer	Alive

4. T.J.F.	2-17-37	Whole cervical stump	Squam. III	Both ligaments	4×1000	Needles 6048	3 mo.	Local healing	Untraced
5. H.H.W.	3- 4-37	Whole cervix	Squam. IV	None	4× 600	Capsules 3600	4 yr. 9 mo.	Cervix healed; ligaments tense	Alive
6. H.O.R.	3-19-37	Small nodular cervix	Squam. II	Both ligaments	4×1200	Capsules 3600	4 yr. 9 mo.	Cervix healed; ligaments tense	Alive
7. E.S.B.	3-20-37	Cervix and all of vagina	Squam. IV	Both ligaments	4×1600	Capsules 2200	2 mo.	Local improvement	Untraced
8. T.O.M.	3-22-37	Whole cervix	Adenoca. II	Both ligaments	4×2000	Capsules 2400	4 yr. 9 mo.	Cervix healed—ligament involv.?	Alive
9. L.R.	3-23-37	¾" mass	Squam. III	None	4× 600	Capsules 3600	6 mo.	No evidence of cancer	Dead—unknown cause
10. J.W.S.	4- 1-37	½" mass	Squam. III	None	4× 600	Capsules 3750	4 yr. 8 mo.	No evidence of cancer	Alive
11. A.M.S.	4- 5-37	Cervical canal	Adenoca. III	None	4× 600	Capsules 3450	4 yr. 8 mo.	No evidence of cancer	Alive
12. G.H.H.	4- 6-37	Whole cervix	Squam. III	None	4× 600	Capsules 3500	4 yr. 8 mo.	No evidence of cancer	Alive
13. A.S.	4-13-37	Cervical canal	Squam. III	None	4× 600	Capsules 3700	4 yr. 8 mo.	No evidence of cancer	Alive
14. L.T.	4-22-37	Small cervical crater	Squam.	Lt. ligament	4×1800	Capsules 1500		Did not return	Dead
15. G.S.	5- 3-37	2" mass ant. lip	Squam. III	Pulmonary and abdominal	4× 600	Capsules 3600	6 mo.	Local healing	Untraced
16. E.D.	5-22-37	Whole cervix	Squam. III	Both ligaments	4× 600	Capsules 3600		Did not return	Untraced
17. L.S.	7-12-37	Cervical canal	Adenoca. III	Both ligaments	4× 600	Capsules 3300	2 mo.	Local healing	Untraced
18. D.E.	7-24-37	Whole cervix	Squam. IV	Lt. ligament	4× 600	Capsules 4800	3 mo.	Vesicouterine fistula; local healing	Died 3 yr. later
19. T.L.H.	7-29-37	Whole cervix	Squam. III	Both ligaments		Needles 5614	4 mo.	Local healing	Dead
20. M.J.T.	8-18-37	¾" crater	Squam. III	None	4× 600	Capsules 4200	8 mo.	Deep pelvic extension	Dead
21. S.V.Mc.	9-19-37	Nodular cervix	Squam. III	Both ligaments	4×2000 4×1500	Capsules 4200	8 mo.	Deep pelvic extension	Untraced
22. L.M.	9-22-37	Large crater	Squam. III	Both ligaments; uremia	4× 800	Capsules 3900	8 days	No change	Dead
23. A.P.B.	9-27-37	Whole cervix	Squam. III	Both ligaments	4× 600 4×2500	Capsules 3600	6 mo.	Local healing Ligament unchanged	Untraced
24. J.M.J.	10- 7-37	Whole cervix	Squam. IV	Lt. ligament	4× 600 4×3000	Capsules 3600 Needles 3952	7 mo.	Local healing Ligament unchanged	Untraced
25. J.S.	10-15-37	Whole cervix	Squam. III	Both ligaments	4× 600	Capsules 3900	1 yr. 1 mo.	Local healing; deep extension	Untraced
26. O.M.J.	11- 8-37	Whole cervix; vaginal wall	Squam. I	None	4× 600	Capsules 3600	3 mo.	No evidence of cancer	Untraced
27. E.W.	11-22-37	Whole cervix; vaginal wall	Squam. III	None	4× 600	Capsules 3800		Did not return	Dead

PATIENTS TREATED IN 1938

1. G.H.	1- 4-38	Whole cervix	Squam. III	None	4× 600	Capsules 4100	3 yr. 11 mo.	No evidence of cancer	Alive
2. H.C.H.	1-17-38	2" pedunculated mass	No report	None	4× 600	Capsules 4100	11 mo.	No evidence of cancer	Dead—kidney stone
3. J.T.B.	1-18-38	¾" crater	Squam. III	None	4× 600	Capsules 3900 Capsules 1800	18 mo.	Deep extension	Untraced
4. W.S.C.	2- 3-38	Whole cervix	Squam. II	None	4× 600	Capsules 3600	3 yr. 10 mo.	Cervix healed; lt. ligament tense	Alive
5. H.H.J.	2- 4-38	Whole cervix	Squam. I	Ligaments doughy	4× 600	Capsules 4500	3 yr. 10 mo.	No evidence of cancer	Alive
6. E.H.	2- 8-38	Indurated cervical stump	Squam. III	None	4× 600 12× 210	Capsules 3600 Needles 4628	3 yr.	Rectovag. fistula Deep. Extension	Dead
7. M.L.	2-16-38	2" mass cervical stump	Adenoca. I	Ligaments tense	4× 250	Needles 4628	3 yr. 10 mo.	No evidence of cancer	Alive
8. H.C.B.	2-21-38	Whole cervical stump	No report	Both ligaments	4×2100	Needles 5624	2 yr. 1 mo.	Cervix healed; deep extension	Untraced
9. A.D.H.	2-22-38	Ant. lip	Squam.	None	4× 600	Capsules 3800	3 yr. 10 mo.	Cervix healed; ligaments tense	Alive
10. A.J.Y.	3- 4-38	Whole cervix	Squam. III	None	4× 400	Capsules 4100	1 yr.	Deep pelvic extension	Untraced
11. G.M.H.	3- 4-38	Whole cervix; vaginal walls	Squam. III	Both ligaments	4× 400	Capsules 3700	5 mo.	Vaginal recurrence	Untraced
12. J.I.B.	3- 7-38	Whole cervix	Squam. III	Both ligaments	4×2200	Treat. Incomplete		Did not return	Untraced
13. D.N.B.	3-11-38	Whole cervix	Adenoca. II	Lt. ligament	4× 400	Capsules 3700	5 mo.	No evidence of cancer	Untraced
14. J.H.B.	3-31-38	Whole cervix	Squam. III	Both ligaments	4× 250	Capsules 3600	1 yr. 4 mo.	Cervix healed; ligaments tense	Dead
15. H.S.S.	4- 4-38	Massive tumor	Squam. IV	Both ligaments	4×3000	Capsules 1200	1 yr.	Marked improvement	Dead
16. J.W.P.	4-11-38	Whole cervix	Squam. II	None	4× 250 4×2200	Capsules 4000	3 yr. 8 mo.	No evidence of cancer	Alive

TABLE II—*Continued*

Case	Treatment Started	Primary Lesion	Pathology	Extension	Roentgen Rays r	Radium mg-hr.	Observed	Last Examination	Outcome
				PATIENTS TREATED IN 1938—(*Continued*)					
17. S.P.G.	4-11-38	Whole cervix	Squam. IV	None	4 × 250	Capsules 4000	3 yr. 8 mo.	No evidence of cancer	Alive
18. J.H.B.	4-20-38	Cervical canal	Squam. III	None	4 × 250	Capsules 3800	3 yr. 8 mo.	No evidence of cancer	Alive
19. E.M.C.	4-25-38	High cervical canal	Squam. III	Both ligaments	4 × 250 4 × 2000	Capsules 4100	3 yr. 8 mo.	Deep extension Ureteral stricture	Dead
20. L.J.	4-28-38	Post. lip; vaginal walls	Squam. III	None	4 × 250 4 × 2200	Capsules 3600	3 yr. 7 mo.	No evidence of cancer	Alive
21. J.B.H.	5- 7-38	¾″ mass post. lip	Squam. I	None	4 × 600	Capsules 3600	3 yr. 7 mo.	No evidence of cancer	Alive
22. R.H.J.	5-18-38	2″ mass ant. lip	Squam. III	None	4 × 600	Capsules 4350	3 yr. 7 mo.	No evidence of cancer	Alive
23. T.D.C.	6- 6-38	Cervical canal	Squam. I	None	4 × 600	Capsules 3600	3 yr. 6 mo.	No evidence of cancer	Alive
24. R.P.	6-16-38	Ant. lip	Squam.	None	4 × 600	Capsules 3700		Did not return	Untraced
25. N.F.	6-20-38	1½″ mass; vaginal wall	Squam. III	Ligaments doughy	4 × 250 4 × 2250	Capsules 3800	3 yr. 6 mo.	No evidence of cancer	Alive
26. I.A.	6-24-38	Whole cervix	Squam. I	Both ligaments	4 × 600 4 × 600	Capsules 4200 Needles 4433	1 yr.	Local recurrence	Untraced
27. M.D.W.	7- 4-38	1½″ mass post. lip	Squam. III	Lt. ligament	4 × 600	Capsules 2800	2 mo.	Cervix healed; deep extension	Died 3 yr. later
28. J.R.C.	9-20-38	Whole cervix	No report	Lt. ligament	4 × 250	Capsules 4000	3 yr. 3 mo.	No evidence of cancer	Alive
29. J.F.L.	10-17-38	Whole cervix	Squam. I	Lt. Ligament	4 × 600	Capsules 4100 Capsules 2400	3 yr. 2 mo.	Cervix healed; ligament tense	Alive
30. D.E.Mc.	11-25-38	½ cervix	Squam. III	None	4 × 600	Capsules 3800	3 yr. 1 mo.	No evidence of cancer	Alive
				PATIENTS TREATED IN 1939					
1. W.H.M.	1-16-39	Nodular cervix	Squam. III	Lt. ligament	4 × 600	Capsules 3000 Capsules 2000	6 mo.	Deep pelvic extension	Dead
2. R.L.J.	1-16-39	1″ mass	Squam. III	None	4 × 600	Capsules 3600	2 yr. 11 mo.	No evidence of cancer	Alive
3. B.K.	1-29-39	Whole cervix; vaginal wall	Squam. III	None	4 × 600	Capsules 4200	4 mo.	No evidence of cancer	Dead
4. B.Mc.	1-31-39	Whole cervix; vaginal wall	Squam. II	None	4 × 600	Capsules 3800	2 yr. 11 mo.	No evidence of cancer	Alive
5. F.W.	2-14-39	Cervical canal	Squam. III	None	2 × 250	Capsules 5100	2 yr. 10 mo.	No evidence of cancer	Alive
6. W.M.S.	2-15-39	3″ mass	Squam. III	?Ligaments slight	4 × 600	Capsules 4400	2 yr. 10 mo.	No recent examination	Alive
7. E.W.	3-17-39	Large crater	Squam. IV	Lt. ligament Hydronephrosis		Needles 5239	6 wks.	No improvement	Untraced
8. M.F.M.	4- 3-39	Cervical canal	Adenoca. I	None	4 × 600	Capsules 4200	2 yr. 8 mo.	No evidence of cancer	Alive
9. V.F.Mc.	5- 5-39	Whole cervix	Squam. II	Lt. ligament	2 × 2800	Needles 5642 Capsules 1000	9 mo.	Deep pelvic extension	Untraced
10. C.A.C.	5-27-39	Cervical canal	Adenoca. I	None	4 × 600	Capsules 3600	2 yr. 7 mo.	No evidence of cancer	Alive
11. E.W.S.	5-29-39	Whole cervix; vaginal wall	Adenoca. I	Lt. ligament	4 × 600	Capsules 4200	2 yr. 7 mo.	No evidence of cancer	Alive
12. H.H.	5-29-39	¾″ mass cerival stump	Squam. IV	?Ligaments slight		Capsules 600 Needles 4032	2 yr. 7 mo.	No evidence of cancer	Alive
13. M.O.	6- 1-39	Nodular cervix; vaginal wall	Squam. III	Lt. ligament	4 × 600 4 × 3120	Capsules 3900	2 yr.	Deep pelvic extension	Dead
14. B.L.	6-10-39	Whole cervix	Squam. IV	Lt. ligament	4 × 600	Capsules 4200	2 yr. 6 mo.	No evidence of cancer	Alive
15. A.D.	6-27-39	Whole cervix	Adenoca. I	None	4 × 600	Capsules 3900	2 yr. 6 mo.	No evidence of cancer	Alive
16. A.D.E.	7-22-39	Whole uterus	Squam. II	Lt. ligament	2 × 600	Needles 6448	2 mo.	Marked improvement	Dead
17. Z.M.N.	7-24-39	Large crater	Squam. III	Both ligaments	4 × 600 4 × 2550	Capsules 4000	4 mo.	Much improvement	Dead
18. F.D.	7-25-39	1½″ mass post. lip	Squam. III	None	4 × 600	Capsules 3900	2 yr. 5 mo.	No evidence of cancer	Alive

19. C.S.	7-27-39	Crater in nodular cervix	Squam. IV	None	4 × 600	Capsules 3900	2 yr. 5 mo.	No evidence of cancer	Alive
20. E.V.K.	8- 8-39	Whole cervix	Squam. III	Both ligaments	4 × 600 2 × 900	Capsules 4200 Needles 3627	7 mo.	Deep pelvic extension	Dead
21. J.C.	8-19-39	Whole cervix	Squam. III	Lt. ligament	2 × 2400	Needles 2418 Capsules 2700	4 mo.	Local healing	Untraced
22. V.R.	9- 1-39	Large crater	Squam. II	Lt. ligament	10 × 210	Capsules 4300	2 yr. 3 mo.	No evidence of cancer	Alive
23. B.T.	9-14-39	Whole cervix	No report	Both ligaments		Needles 5239	9 mo.	Deep pelvic extension	Dead
24. C.N.	9-29-39	Large nodular cervix	Squam. II	Ligaments tense	4 × 600	Capsules 4500	2 yr. 3 mo.	Cervix healed; deep recurrence	Alive
25. J.M.O.	9-30-39	Nodular cervix	Squam. IV	None	4 × 600 6 × 210	Capsules 4200 Capsules 2250	3 mo.	Deep pelvic extension	Dead
26. J.A.D.	10-11-39	Whole cervical stump	Squam. IV	Both ligaments	4 × 600	Needles 5642		Did not return	Untraced
27. L.H.	11-11-39	Whole cervix	Squam. III	Lt. ligament	2 × 1470 6 × 1470	Needles 6048	1 yr. 2 mo.	Deep pelvic tumor	Untraced
28. H.M.H.	11-11-39	Cervical canal	Squam. III	None	4 × 600	Capsules 3600	1 yr.	No evidence of cancer	Untraced
29. D.B.	11-15-39	Polypoid mass	Squam. III	None	4 × 600	Capsules 3600	2 yr. 1 mo.	No evidence of cancer	Alive
30. J.Y.E.	11-18-39	Whole cervical stump	Squam. II	None	2 × 1260	Needles 3627	2 yr. 1 mo.	No evidence of cancer	Alive
31. J.S.B.	11-26-39	Whole cervix	Squam. III	Lt. ligament	2 × 1260	Needles 5239	2 yr. 1 mo.	Deep extension; hydronephrosis	Alive
32. C.D.J.	12- 1-39	½″ mass	Squam. III	None	4 × 600	Capsules 5100	2 yr.	No evidence of cancer	Alive

PATIENTS TREATED IN 1940

1. J.A.P.	1- 1-40	Whole cervix	Squam.	None	4 × 600	Capsules 3700	2 yr.	No evidence of cancer	Alive
2. M.A.B.	1- 5-40	Nodular cervix	Squam. II	None	4 × 600	Prescription lost		Did not return	Untraced
3. E.R.	1-26-40	Whole cervix; vaginal wall	Squam. II	?Slight ligament involvement	4 × 600 4 × 2100	Capsules 4000	2 yr.	Local healing; hydronephrosis	Alive
4. W.G.	1-31-40	Small ulcer	Squam. III	None	4 × 600	Capsules 3700	1 yr. 11 mo.	No evidence of cancer	Alive
5. P.R.J.	2-16-40	Post. lip; vaginal wall	Squam. III	None	4 × 600	Capsules 3900	1 yr. 10 mo.	No evidence of cancer	Alive
6. E.D.	2-23-40	Large crater	Squam.	Both ligaments	4 × 600	Capsules 2100	6 mo.	Deep pelvic extension	Dead
7. M.H.G.	2-24-40	Nodular cervix	Squam. III	None	4 × 600	Capsules 4250		Did not return	Untraced
8. A.Mc.	2-26-40	Whole cervix	Squam. IV	None	4 × 600	Capsules 3900	1 yr. 10 mo.	No evidence of cancer	Alive
9. W.H.K.	2-29-40	Cervical canal	Squam. III	Lt. ligament	4 × 600	Capsules 3700	1 yr. 10 mo.	Cervix healed; lt. ligament involv.?	Alive
10. V.E.Mc.	3- 9-40	½″ cervix	Squam. III	?Lt. ligament	2 × 1200 4 × 2250	Capsules 3800	1 yr. 9 mo.	No evidence of cancer	Alive
11. J.C.C.	3-23-40	Whole cervix	Squam. II	None	4 × 600	Capsules 3600		Did not return	Untraced
12. R.L.A.	4-18-40	Whole cervix; vaginal wall	Squam. III	Lt. ligament	4 × 600	Capsules 3450	1 yr. 8 mo.	Cervix healed; ligament tense	Alive
13. W.P.H.	5- 2-40	Nodular cervix	Squam. III	Lt. ligament	4 × 600	Capsules 4100	6 mo.	No evidence of cancer	Alive
14. B.M.	5-24-40	Cervix; vaginal and bladder	Adenoca. II	Lt. ligament	4 × 600	Capsules 4000	11 mo.	Cervix healed; mass in pelvis	Dead
15. S.F.H.	5-27-40	Whole cervix	Squam. II	Both ligaments	4 × 600 4 × 3000	Capsules 3900	7 mo.	Frozen pelvis	Dead
16. F.P.	6-13-40	Large crater	No report	Both ligaments	4 × 600	Capsules 3800		Did not return	Dead
17. A.B.H.	6-18-40	Cervical canal	Squam. IV	None	4 × 600	Capsules 4300	1 yr. 6 mo.	No evidence of cancer	Alive
18. R.J.G.	7-10-40	Whole cervix	Squam. III	Both ligaments	4 × 600	Capsules 4500	1 yr. 5 mo.	Bladder and ligament involv.	Alive
19. S.C.S.	7-25-40	Cervical canal	Adenoca. II	None		Capsules 3650 Needles 1612	1 yr. 5 mo.	No evidence of cancer	Alive
20. O.W.D.	7-27-40	Cervical canal	Squam. I	None	4 × 600	Capsules 3800	1 yr. 5 mo.	No evidence of cancer	Alive
21. J.C.Mc.	9-13-40	Malignant polyp	Squam.	None	4 × 1250	Capsules 3200	1 yr. 3 mo.	No evidence of cancer	Alive
22. R.D.	9-16-40	Ulcer external os	Squam. III	None	4 × 600	Capsules 3900	1 yr. 3 mo.	No evidence of cancer	Alive
23. C.A.P.	10-17-40	Cervical and vaginal walls	Squam. III	Both ligaments	4 × 3380	Capsules 1500	6 mo.	Local improvement	Dead
24. A.L.	10-18-40	Nodular stump	Squam. IV	Lt. ligament	2 × 1200	Needles 4433	2 mo.	Deep pelvic extension	Untraced
25. E.A.A.	10-19-40	Nodular cervix with crater	Squam. III	Both ligaments	4 × 600	Needles 5642	1 yr. 2 mo.	Cervix healed; deep extension	Alive
26. J.A.M.	10-22-40	Large mass in stump	Squam. III	None	2 × 1200	Needles 2010	1 yr. 2 mo.	No evidence of cancer	Alive
27. J.H.E.	11- 6-40	Whole cervix; vaginal wall	Squam. IV	Both ligaments	2 × 1200	Capsules 1200 Needles 6048	6 wk.	Frozen pelvis	Untraced
28. D.L.	11-14-40	Whole cervix; vaginal wall	Squam. III	Lt. ligament	4 × 3000			Did not return	Dead

electrocoagulation and removed with biting forceps. Although this procedure is condemned by many, it is considered an essential part of our technique because it enables the operator to place radium applicators accurately in intimate contact with the base of the tumor in a dry field, from which all confusing hemorrhage has been eliminated. It also makes it possible for him to obtain several biopsies of ample size from various portions of the neoplasm. A moderate temperature elevation usually follows the coagulation for a day or two. In the rare case in which a troublesome infection persists, sulphonamide therapy has been found quite effective.

Roentgen therapy was considered to be of secondary importance in the early and border line cases, but single doses of 600 r were given to each of four 15 cm. portals, using 200 kv. equipment, while the patient was hospitalized for radium therapy. Two portals were laid out over the front of the pelvis and two over the back. In most instances the radium applications and the roentgen treatments were given on alternate days. This plan was economical in that it enabled the patient to receive all of her therapy within a period of a week.

The cases which did not respond well to this procedure were rarely improved by the subsequent administration of more intensive roentgen therapy. Tod[24] made a similar observation and states that she obtained a higher percentage of cures in clinical Stages I and II when no roentgen therapy was added to her radium technique. The use of intensive preliminary roentgen therapy in these cases not only increases the incidence of irradiation sequelae, but produces so much contraction of the upper vaginal vault that London spools or other types of applicators designed to bring radium near the broad ligaments cannot be properly placed.

When the disease was well advanced, and particularly when there was much infection present, roentgen therapy was given first. In these cases palliation was the primary objective, and measures designed to relieve symptoms seemed more important than a vain attempt at a cure, followed by prolonged irradiation sequelae. In most instances four portals were used, as in the more favorable cases. Lateral portals were not used, because, in my opinion, they increase the danger of spontaneous hip fractures and add little to the efficiency of the treatment. Doses of 200 r were given to each of two portals daily, with 200 kv. equipment, until total amounts of 1,200 to 2,400 r had been administered to each area. When the smaller doses were given, the roentgen series was followed immediately by the radium therapy previously described, but radium applications were delayed for a period of three or four weeks when the more intensive external irradiation was utilized. Intravaginal roentgen therapy which of necessity increases the dosage reaching the anterior rectal wall was never used. A study of the histories of patients developing irradiation fractures of the hip indicates that most of them received repeated series of roentgen treatments given at intervals of six to eight weeks. For this reason it was assumed that the maximum palliation was produced when the above plan of treatment was completed, and further irradiation was rarely attempted. In those cases in which it was carried out, it seemed to be of little value. Certainly it should be delayed for a period of six to eight months, if it is to be given at all.

RESULTS

Although the technique described above is somewhat unorthodox, it should be judged by the results summarized in Table 1. Heyman[9] reports that the average five year survival rate in a group of 10,970 cases of carcinoma of the cervix, treated in the best irradiation clinics in the world, is 26 per cent. Although the group of cases reported in this paper is not large, and only a relatively small number have been followed for more than five years, the figures indicate that the five year survival rate will be as good as that averaged by other

clinics. Of more importance is the fact that the only complications which might be attributed to the effects of irradiation are four fistulae. Although 43 of the patients could not be traced during the entire period of observation, most of them were observed long enough to rule out the occurrence of irradiation sequelae. None of them developed rectal ulceration, bladder ulceration intestinal obstruction, serious infections or fractured hips. A fair number died with strictures of the ureters, but the incidence was no higher than that observed in untreated cases.

SUMMARY

An irradiation technique is described which produced end-results equal to those reported by other clinics, with no serious irradiation sequelae, except four fistulae. All techniques should be judged on the basis of irradiation complications, as well as five year survival rate.*

REFERENCES

1. BEHNEY, C. A. Advanced carcinoma of the cervix, with report of 166 necropsies. *Am. J. Obst. & Gynec.*, 1933, *26*, 608–614.
2. BENTHIN. Rectoscopic picture of patients irradiated with radium. *Arch. f. Gynäk.*, 1923, *120*, 299.
3. BUIE, L. A., and MALMGREN, G. E. Factitial proctitis; justifiable lesion observed in patients following irradiation. *Internat. Clin.*, 1930, *3*, 68–77.
4. CORSCADEN, J. A., KASABACH, H. H., and LENZ, M. Intestinal injuries after radium and roentgen treatment of carcinoma of the cervix. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 871–894.
5. COSBIE, W. G. Complications of irradiation treatment of carcinoma of the cervix. *Am. J. Obst. & Gynec.*, 1941, *42*, 1003–1008.
6. DALBY, R. G., JACOX, H. W., and MILLER, N. F. Fracture of the femoral neck following irradiation. *Am. J. Obst. & Gynec.*, 1936, *32*, 50–59.
7. EVERETT, H. S. Effect of carcinoma of cervix uteri and its treatment upon the urinary tract. *Am. J. Obst. & Gynec.*, 1939, *38*, 889–906.
8. HEALY, W. P., and FRAZELL, E. L. Methods and results of treatment in carcinoma of the cervix at the Memorial Hospital. *Am. J. Obst. & Gynec.*, 1937, *34*, 593–606.
9. HEYMAN, J. Annual Report on the Results of Radiotherapy in Cancer of the Uterine Cervix. League of Nations Health Organization, P. A. Norstedt & Son, Stockholm, 1941.
10. JEANNENEY, G., and WANGERMEZ, C. Cicatricial stenoses of the rectum, following radium therapy of cancer of the cervix. *J. de méd. de Bordeaux*, 1929, *59*, 461–464.
11. JONES, T. E. Intestinal complications from prolonged radium and x-ray irradiation for malignant conditions of the pelvic organs. *Am. J. Obst. & Gynec.*, 1935, *29*, 309–316.
12. MARTIN, C. L., and ROGERS, F. T. Intestinal reaction to erythema dose. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 11–19.
13. MARTIN, C. L., and ROGERS, F. T. Roentgen-ray cachexia. AM. J. ROENTGENOL. & RAD. THERAPY, 1924, *11*, 280–286.
14. MARTIN, C. L., and ROGERS, F. T. Effect of irradiation on the ureter. AM. J. ROENTGENOL. & RAD. THERAPY, 1926, *16*, 215–218.
15. MARTIN, C. L., and ROGERS, F. T. Broad ligament extension in carcinoma of the cervix. AM. J. ROENTGENOL. & RAD. THERAPY, 1926, *15*, 336–344.
16. MARTIN, C. L. Weak radium needle technique in carcinoma of the cheek. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 226–236.
17. MILLER, N. F., and FOLSOME, C. Carcinoma of the cervix. *Am. J. Obst. & Gynec.*, 1938, *36*, 545–561.
18. PEMBERTON, F. A. Complications of radiation treatment in gynecology. *Am. J. Obst. & Gynec.*, 1932, *24*, 552–561.
19. SCHMITZ, H. Classification of uterine carcinoma for study of efficacy of radium therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1920, *7*, 383–395.
20. SMITH, F. R. Incidence of vaginal fistulae in patients with carcinoma of the cervix. *Am. J. Cancer*, 1934, *22*, 52–58.
21. STONE, R. S., and ROBINSON, J. M. Roentgen irradiation of pelvis in carcinoma of cervix uteri. *Radiology*, 1941, *36*, 521–533.
22. STRAUSS, H., and MCGOLDRICK, J. L. Fracture of the femoral neck following roentgen therapy for gynecological malignancy. *Am. J. Obst. & Gynec.*, 1941, *41*, 915–934.
23. TODD, T. F. Rectal ulceration following irradiation treatment of carcinoma of cervix uteri. *Surg., Gynec. & Obst.*, 1938, *67*, 617–631.
24. TOD, MARGARET C. Optimum dosage in treatment of carcinoma of uterine cervix by radiation. *Brit. J. Radiol.*, 1941, *14*, 23–29.
25. WHITE, W. C. Irradiation burn of the intestine. *Ann. Surg.*, 1940, *112*, 769–774.
26. WIRTH, J. E., CANTRIL, S. T., and BUSCHKE, F. Analysis of the failure of radiation therapy in carcinoma of the cervix uteri. *Radiation Therapy, Tumor Inst., Seattle*, February, 1940, No. 1, pp. 12–21.

* For discussion see page 515.

AN INSTRUMENT FOR INSERTING MULTIPLE CAPSULES OF RADIUM WITHIN THE UTERUS IN THE TREATMENT OF CORPUS CANCER*

By JAMES F. NOLAN, M.D., *and* A. N. ARNESON, M.D.
ST. LOUIS, MISSOURI

IT IS the opinion of several authors that the best clinical results obtained in the treatment of carcinoma of the body of the uterus have followed the combined use of both irradiation and surgery. One need only consult collected statistics that have been published to justify the value of irradiation.[1,13] It can be said, however, that removal of the uterus, whenever practical, remains the fundamental procedure. The addition of roentgen rays and radium in the treatment of operable cases compromises in no way the value of hysterectomy.

There is evidence that preoperative irradiation is more effective than treatment given after hysterectomy. One factor contributing to the relative superiority for preoperative irradiation must be the greater tissue dose that can be obtained by means of radium applied within the uterus before its removal. Corpus cancer, however, presents technical problems that often make difficult a satisfactory application of radium.

There is general agreement that an intra-uterine tandem is ineffective in most instances. In spite of the fact that the active length of the applicator may extend from the top of the fundus to the external os, a bulky lesion may so distort the cavity that several centimeters of tissue intervene between some tumor cells and the radium sources. In cavities of normal size the tandem may be along the center of the uterus or fall toward one side. If there is a small lesion in one cornu there may be considerable distance between the tumor and nearest radium source. These factors are bound to produce marked irregularities in radiation effect. Gross specimens obtained after tandem treatment usually reveal focal areas of tumor destruction with other regions of unaffected cancer.[2] Due to the small number of sources employed, the contributions from each must be relatively great. For that reason radiation necrosis is not uncommon.

A logical method for increasing the effectiveness of radium treatment is the use of a greater number of sources placed irregularly throughout the uterine cavity. Several years ago, however, Sampson[15] demonstrated many of the difficulties encountered in the attempt to use multiple capsules. Others have feared injury to the uterus, chiefly by perforation of the wall. At the same time several authors including Heyman,[9] Schmitz and Schmitz,[16] Martin,[12] Brown,[4] Friedman,[7] Strauss,[17] Pfahler,[14] Crossen,[5] Kaplan,[11] and others, have devised special techniques of treatment. Most of these methods include the use of several sources of small size containing relatively small amounts of radium. Heyman's technique presents definite advantages. The small, weak, intra-uterine tubes are so constructed that an appreciable distance is obtained between the emanating source and outer wall of the applicator. These are packed singly into the uterine cavity until all available space has been filled.

In 1938 at both the Barnes Hospital and the Barnard Free Skin and Cancer Hospital we began the use of a method requiring a minimum of special apparatus.[2] The attempt was made to approximate the technique devised by Heyman. Radium sources of different size and strength were placed

* From the Department of Obstetrics and Gynecology, and the Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine; and the Barnard Free Skin and Cancer Hospital, St. Louis, Mo. Presented at the Twenty-Seventh Annual Meeting, American Radium Society, Atlantic City, N. J., June 8–9, 1942.

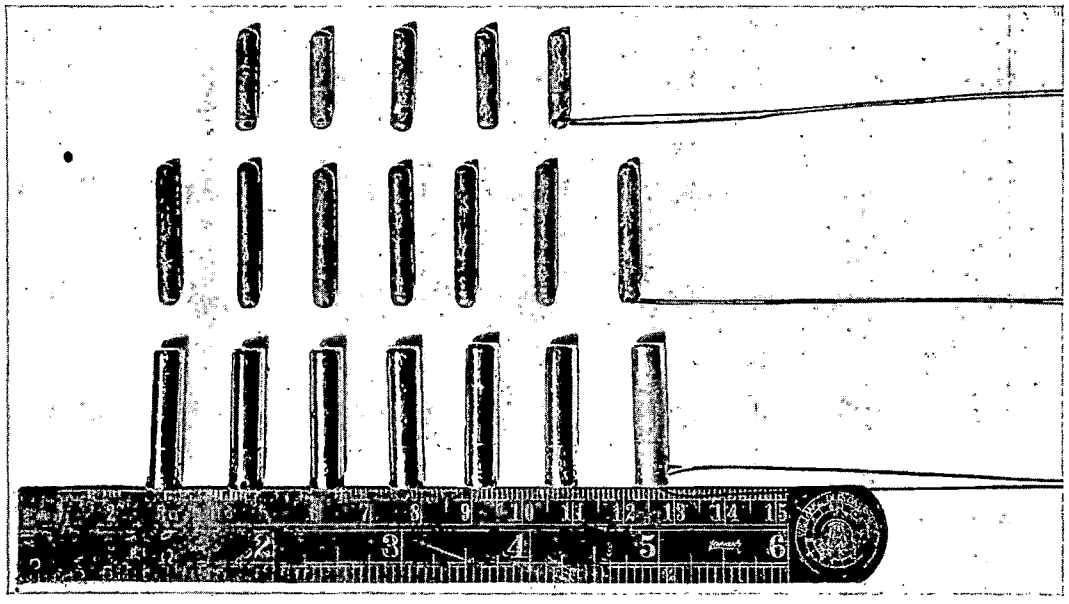


FIG. 1. Brass capsules used for intra-uterine treatment. The longer tubes are for one or more sources of 12.5 mg. radium strength. Those of greater diameter are used in the cervical canal. The shorter capsules contain 6.0 mg. radium in removable platinum cells.

within the uterus by means of uterine dressing forceps. Small strips of gauze were used in the attempt to keep the radium tubes in place, and also to obtain some distance around the stronger sources. Each application was checked by means of a roentgenogram. The method has not proved entirely satisfactory. In many instances it was difficult to get the tubes in place, and not infrequently rather marked irregularities in radiation effect were noted in specimens obtained at hysterectomy. The incidence of severe necrosis was, however, decidedly less than for tandems.

More recently the attempt has been made to improve the method. The points and eyelets of several monel metal needles were ground away to obtain sources with active lengths corresponding more closely to the over-all length of the tube. The shortened needles contain approximately 12.5 mg. radium each, and are about twice the length of removable platinum cells. Brass tubing was used to make sheaths of equal external diameters, but of different lengths. The longer brass sheaths will contain one of the 12.5 mg. sources, and the shorter ones hold 6.0 mg. in removable platinum cells. By that means several sources are obtained that contain approximately the same radium strength per centimeter length.

In some instances it may be advisable to employ stronger sources, or sheaths of greater external diameter. If the cervix is involved, for instance, it is more practical to use stronger tubes in that region because there are no others in parallel to contribute radiation. There should always be a sheath of greater diameter in the cervical canal to maintain dilatation adequate for removal of those of lesser diameter deeper in the uterus. For the above reasons several sheaths were made with external diameters about twice that of those first described and with internal diameters adequate for two of the 12.5 mg. tubes (total strength 25 mg. radium). A photograph of the sheaths of three different sizes is shown in Figure 1. The total filter for each, including the metal wall of the different radioactive tubes, is equivalent to 2.0 mm. brass.

It became necessary to devise an instrument for introducing radium into the

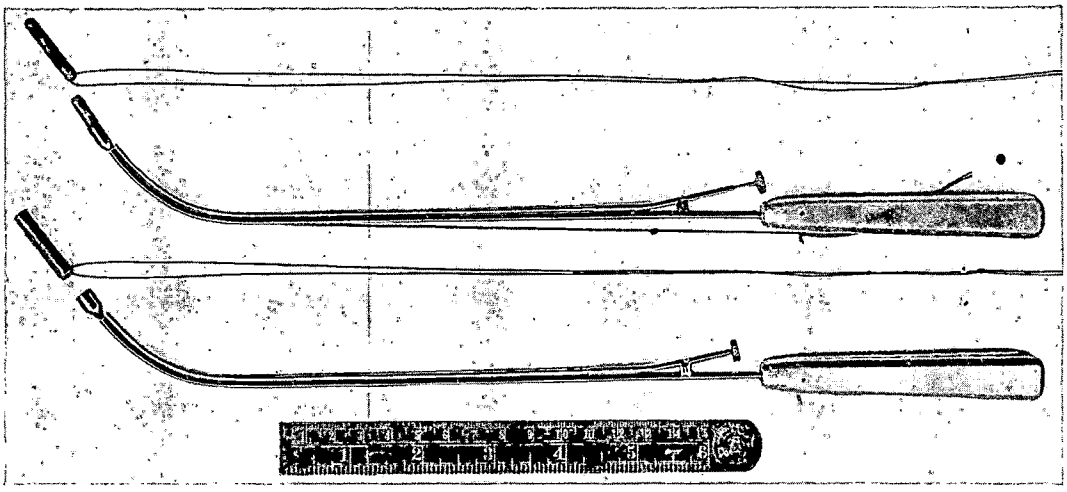


FIG. 2. Instruments used for inserting tubes of radium into the uterus.

uterus. A cup-shaped adapter was attached to a rod, or shank, curved to accommodate the angle of the uterus. A slit in the side of the cup provides an opening through which the ligature from the radium source can be fitted into a groove along the convex surface of the shank, and fixed to a small peg on the handle of the instrument. Along the concave surface of the shank is a small tube through which a wire ejector projects into the cup-shaped adapter. The ejector must be partially withdrawn for loading the instrument. After the radium is passed to the desired position within the uterus, the ligature is detached from the peg on the handle, and the ejector pressed in to discharge the source. Due to the fact that capsules of two different diameters are employed it is necessary to have introducers with adapters for each size. For convenience there should be more than one instrument of each size. A photograph of the introducers is shown in Figure 2. It should be noted that the use of multiple sources of radium within the uterus is not a new method of treatment. The technique presented here is essentially a modification of the method described by Heyman.[9]

From 1938 to 1941, inclusive, a total of 69 patients with cancer of the corpus uteri were treated with radium at the Barnard Free Skin and Cancer Hospital, and on the teaching service at the Barnes Hospital. There is no justification for attempting an analysis of clinical results, but the number of patients is believed adequate for a preliminary report upon the methods of treatment. During this period a transition was made from the use of intra-uterine tandems to multiple sources. Of the total number, tandems were employed in 24 patients, and multiple sources in 45. Among those in whom multiple tubes of radium were used, the earlier gauze method was employed in 36 individuals and the newer introducer in nine. It was during this period also that a transition was made to preoperative radium in all patients treated by hysterectomy. During the first half of the four year period a good many operable patients were treated by surgery alone, or in conjunction with roentgen irradiation. These are not here included, and their loss to radium treatment accounts for the relatively low hysterectomy rate to be shown later.

In Table 1 is shown the number of patients treated with radium applied by the different methods. With the exception of those in whom tandems were employed they have been grouped according to the depth of the uterine cavity. This is done to show variation in the average number of radium sources used, and in average total doses employed. It can be seen, that, for

multiple capsules, the number of sources placed in the uterus increases with depth of the cavity. For uteri of a given size the average number of sources is greatest among patients treated with the introducer devised recently. There is shown also an increase in average total dose with uterine cavities of greater depth. Among those measuring from 4 to 5 inches treated with the introducer, however, this increase is not apparent. That is due to the fact that only 2 patients fall into the group in question. One of those had been irradiated elsewhere, and only a small additional dose of radium was given prior to hysterectomy. The most significant finding in the table is the average dose per source. For tandems the amount contributed by each tube is enormous. Necrosis is to be expected. There is a marked decrease in dose per source among the first multiple-capsule treatments in which gauze was used. As a result the amount of necrosis was materially lessened, despite the fact that the minimum tumor dose was increased materially. There is evidence that the average dose per source will become even less among patients treated with the newer method.

TABLE I

TOTAL NUMBER OF PATIENTS TREATED WITH RADIUM FOR CORPUS CANCER FROM 1938 TO 1941, INCLUSIVE

Number of Cases	Depth of Uterus inches	Number of Sources	Total Dose mg-hr.	Dose per Source mg-hr.
		Intra-uterine Tandem		
24		2–3	4000	1800
		Multiple Capsules with Gauze		
19	3–4	6	4800	800
12	4–5	8	5600	700
5	5–6	10	6500	650
		Multiple Capsules with Introducer		
7	3–4	10	4800	480
2	4–5	12	4800	400

With the exception of those in whom tandems were used the patients have been grouped according to the depth of the uterus. With increase in uterine depth there can be seen increase in the number of sources used and total doses employed. For multiple capsules there has been a marked decrease in dose contributed per source.

So far as possible radium treatment has been followed by hysterectomy. The gross specimen obtained at operation supplies excellent material for studying the effect of irradiation. Among those in whom radical surgery could not be done the attempt has been made to evaluate treatment by means of curettement done at varying periods after complete irradiation. In a good many instances no additional procedure has been performed. Many of these patients had advanced lesions, and several are now dead. Others have refused examination by curettement. Evaluation of the group in whom no additional procedure has been done must wait for analysis of five year results. In Table II can be seen the incidence of persistent tumor as determined by hysterectomy or curettement. Among patients treated by intra-uterine tandems there were 16 followed by one of the above procedures. Residual tumor was found in

TABLE II

COMPARISON OF THE INCIDENCE OF PERSISTENT TUMOR FOUND AT HYSTERECTOMY OR BY CURETTEMENT IN CASES TREATED BY THE TWO DIFFERENT METHODS FOR APPLYING RADIUM

Procedure	Number of Cases	Residual Tumor	No Tumor Found	Approximate Percentage without Tumor
		Intra-uterine Tandem		
Hysterectomy	8	7	1	
Curettement	8	7	1	
None	8			
Total	24	14	2	15
		Multiple Capsules		
Hysterectomy	18	3	15	
Curettement	11	3	8	
None	16			
Total	45	6	23	80

all except two. Upon that basis cancer was destroyed by irradiation in only about 15 per cent. Among those treated by means of multiple capsules there are 18 upon whom hysterectomy has been performed. Residual tumor was found in only three. Curettement was done in 11 others, with residual tumor found in three. It should be noted that, among 29 patients treated with multiple capsules followed by hysterectomy or curettement, no residual tumor was identified in 23, or about 80 per cent.

Healy and Brown[8] have reported that histologic examination of uteri removed after treatment with an intra-uterine tandem revealed persistent carcinoma in possibly 1 out of every 3 patients. The residual tumor was often degenerated markedly, and appeared to be unviable. The authors noted that uteri of larger size were more apt to show persistent cancer, and concluded that enlargement of the uterus presented a more serious prognosis.

The presence or absence of identifiable carcinoma persisting in a uterus removed after preoperative irradiation does not provide a positive index as to the clinical result to be expected. Failures may occur among those showing no evidence of cancer due to the survival of some tumor cells in tissues not removed surgically. It can also be stated that those showing an abundance of persistent cancer will be cured if all the tumor is limited to the uterus itself. Donovan and Warren[6] have questioned the value of preoperative irradiation upon the basis of the high incidence of persistent cancer found in specimens obtained at hysterectomy. In the patients here reported the incidence is high among those treated with tandems, but remarkably low among those in whom multiple capsules were used. It should be noted that, in most clinical and statistical reports that have been published, the intra-uterine tandem has been the method generally employed for applying preoperative radium. The use of multiple capsules has made practical the administration of greater amounts of radiation. It is reasonable to believe, therefore, that the technique in question will, for several reasons, result in some improvement in clinical results. The margin of improvement is not expected to be great. It will apply chiefly to the occasional patient with moderate involvement of tissues adjacent to the uterus not removed surgically. The volume of tissue treated adequately by an intra-uterine tandem is not great. The use of multiple capsules will, due to the greater doses that can be employed, result in some increase in the volume of tissue receiving an adequate dose.

TABLE III

PERSISTENCE OF CANCER IN SPECIMENS OBTAINED BY HYSTERECTOMY AT DIFFERENT INTERVALS AFTER TREATMENT BY MULTIPLE TUBES OF RADIUM INTRODUCED INTO THE UTERUS

Time after Radium	Number of Cases	Residual Tumor	No Tumor Found
1 week	3	0	3
2 weeks	4	1	3
8 weeks	4	1	3
Over 8 weeks	7	1	6
	18	3	15

In the attempt to combine preoperative irradiation with surgery in the treatment of operable cases there must be an optimum time for hysterectomy. If the tumor is not destroyed completely there is every reason to believe that the uterus should be removed before recovery of inadequately treated carcinoma has occurred. Evidence of tumor recovery can be found occasionally in uteri showing persistent carcinoma. Those specimens are usually the ones removed about six weeks after radium treatment. The presence of tumor showing irradiation effect adjacent to areas of fully viable and actively growing carcinoma was interpreted as evidence of recovery in a study of regression of cervical cancer.[3] It is well within the limits of probabilities that corpus cancer might be expected to show evidence of recovery within six weeks. For that reason one may assume that, whenever practical, hysterectomy should be done before that period has elapsed.



FIG. 3. Multiple sources of radium within a uterus of average size presenting no marked irregularities. Capsules in the fundus are lying transversely to the axis of the uterus.

In the attempt to better evaluate the optimum time for hysterectomy the interval between radium treatment and removal of the uterus has been varied deliberately. The results obtained in this experiment are given in Table III. It is significant that an absence of residual tumor has been noted in specimens removed as early as one week after radium treatment. No definite commitment can be made upon the optimum time for operation, but on the basis of tumor recovery there is evidence that surgery should be employed before six weeks has elapsed.

Each patient treated with multiple capsules has been studied by means of a roentgenogram taken while radium was in place. This procedure has been of value in the attempt to improve the technique. In Figure 3 can be seen an anteroposterior and lateral view made of a patient after multiple capsules had been introduced into the uterus. In the fundus the sources are lying transversely to the axis of the uterus. An arrangement of this sort produces a more uniform radiation effect, but is not easily obtained in every instance. Use of the shortest sources increases the possibility for placing tubes in that position. Another roentgenogram shown in Figure 4 illustrates the use of sources of greater diameter in the cervical canal. By this means the canal is kept sufficiently dilated for easy removal of the remaining tubes. It should be noted again that, among patients in whom the cervix is involved by a downgrowth of cancer, the intracervical capsule should be of greater strength, and radium should also be applied in the vagina.

Roentgenograms of a third case are shown in Figure 5. There are no capsules lying transversely across the fundus, and a tube of greater diameter was not used in the cervix. The roentgenograms are shown, however, for reasons of continuity. The uterus was removed two weeks after radium treatment. Two views of the gross specimen obtained at hysterectomy are shown in Figure 6. Upon opening the uterus the cavity presented a shaggy lining that could be stripped away with ease leaving a smooth, glistening surface except in the region of the fundus. The upper uterus probably received a lesser dose than more

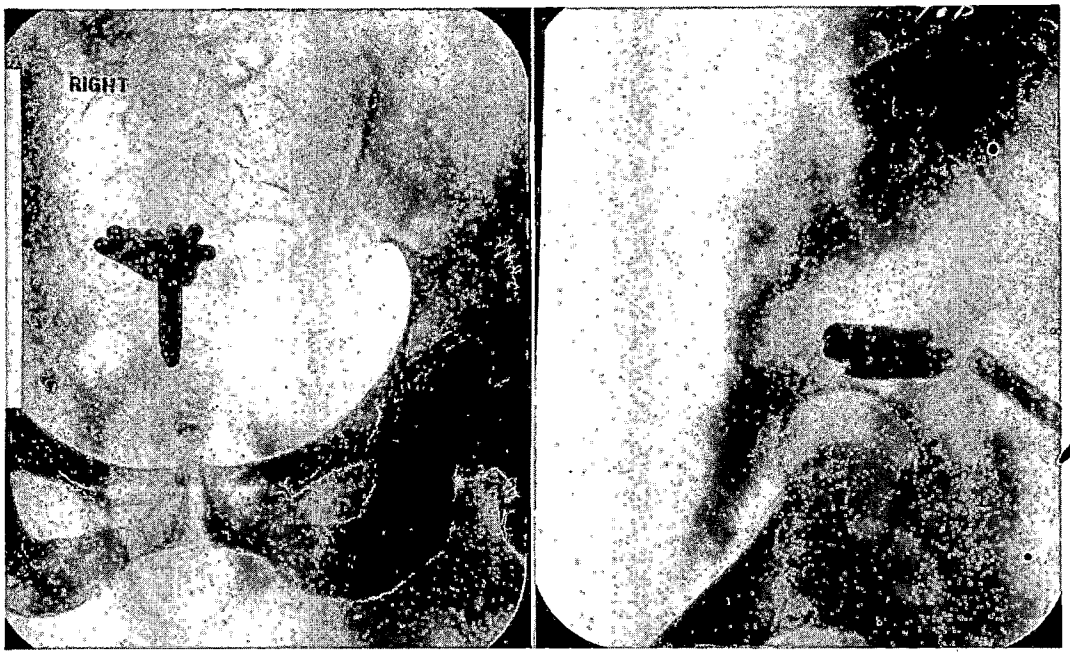


FIG. 4. Multiple sources of radium within a uterus somewhat larger than average. A capsule of greater external diameter is located in the cervix. By that means the canal is kept dilated for safe removal of the deeper tubes. The source in the cervix is of greater radium strength than those in the upper part of the uterus.



FIG. 5. Lateral and anteroposterior roentgenograms illustrating the radium treatment of a case operated upon two weeks later. The gross specimen is shown in Figure 6.



Fig. 6. Uterus removed from a patient two weeks after radium treatment shown roentgenographically in Figure 5. Superficial lesion presenting a degenerated and shaggy endometrial lining that was easily pulled away except in the fundus. Adherence in the upper uterus may be associated with a lesser dose falling in that region.

central regions. The finding of such a loosely attached endometrium is not unusual, but occurs chiefly in the more superficial types of lesions. Evidence of the lack of infiltration can be seen in the photomicrograph shown in Figure 7. This specimen was taken from a region where the lining of the cavity had been stripped away

Histologic examination of such degenerated endometrium has rarely shown viable cancer. Few cellular elements remain, and the endometrium is replaced chiefly by exudate. The exudate undergoes gradual organization, as can be seen in Figure 8.



Fig. 7. Photomicrograph taken from the uterus shown in Figure 6, and illustrating the lack of infiltration. Section is from a part of the uterus from which the endometrial lining was pulled away.

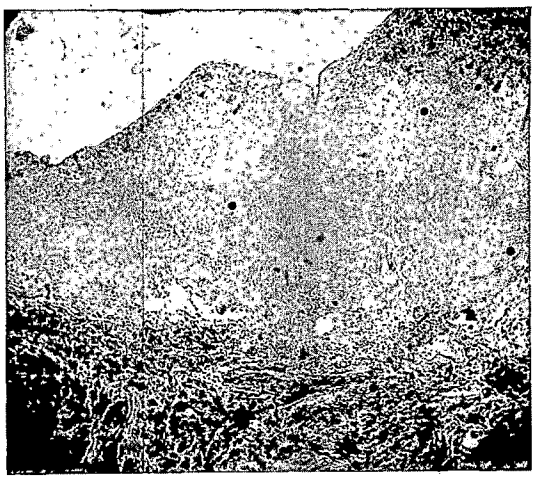


Fig. 8. Photomicrograph showing well developed organization of the inflammatory exudate replacing endometrium, and presumably tumor, in a uterus removed six weeks after radium treatment. Section from near fundus.



FIG. 9. Photomicrograph taken from near the cervix of the same specimen as shown in Figure 8, and showing the absence of necrosis and marked uniformity of irradiation effect at the two extremes of the uterus.

The section was taken from a uterus removed six weeks after radium treatment. Organization of the inflammatory exudate has taken place, and there is a beginning single layered growth of epithelium on the surface forming a new lining for the uterine cavity. This particular uterus showed a remarkable uniformity of radiation effect so far as histologic changes were concerned. The section already described was obtained from the fundus. A photomicrograph of tissue from the cervix is shown in Figure 9. Both of these sections show destruction of epithelial cells without residual necrosis. In each there is a comparable degree of injury to muscle and connective tissue as well as blood vessels. Such a uniform distribution of radiation effect is not obtained in all patients treated with multiple capsules, however, as can be seen in Figure 10. There is no question as to the presence of viable carcinoma in this specimen removed two weeks after radium was applied. There were, however, some areas in which complete degeneration of tumor had occurred.

There is one case for whom particular discussion is indicated. Roentgenograms taken during radium treatment revealed an atypical arrangement of intra-uterine sources. In both the anteroposterior and lateral views shown in Figure 11 there is evidence that two capsules are outside the uterine cavity. The presence of fever gave additional evidence that the uterus was perforated, and for that reason the radium was removed. One week later a second radium treatment was given without untoward effects. Hysterectomy was done several days afterward. At operation the point of perforation was found extending into a small abscess buried in dense adhesions between the uterus and sigmoid colon. There was no residual tumor found in the gross specimen, and the patient made a satisfactory recovery. Follow-up has extended over a period of nine months without evidence of recurrence. About three months after hysterectomy, however, the patient was re-admitted to Barnes Hospital with symptoms of partial intestinal obstruction. These symptoms subsided under conservative treatment, and no other sequelae have occurred.

It is interesting to note that Heyman, Reuterwall and Benner[10] report a similar experience. In their presentation was published a photograph in which a similar arrangement of intra-uterine sources was

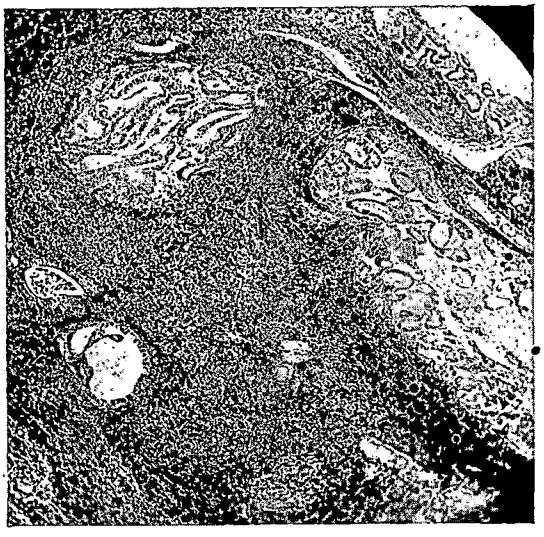


FIG. 10. Photomicrograph showing the persistence of cancer in a uterus removed two weeks after radium treatment.

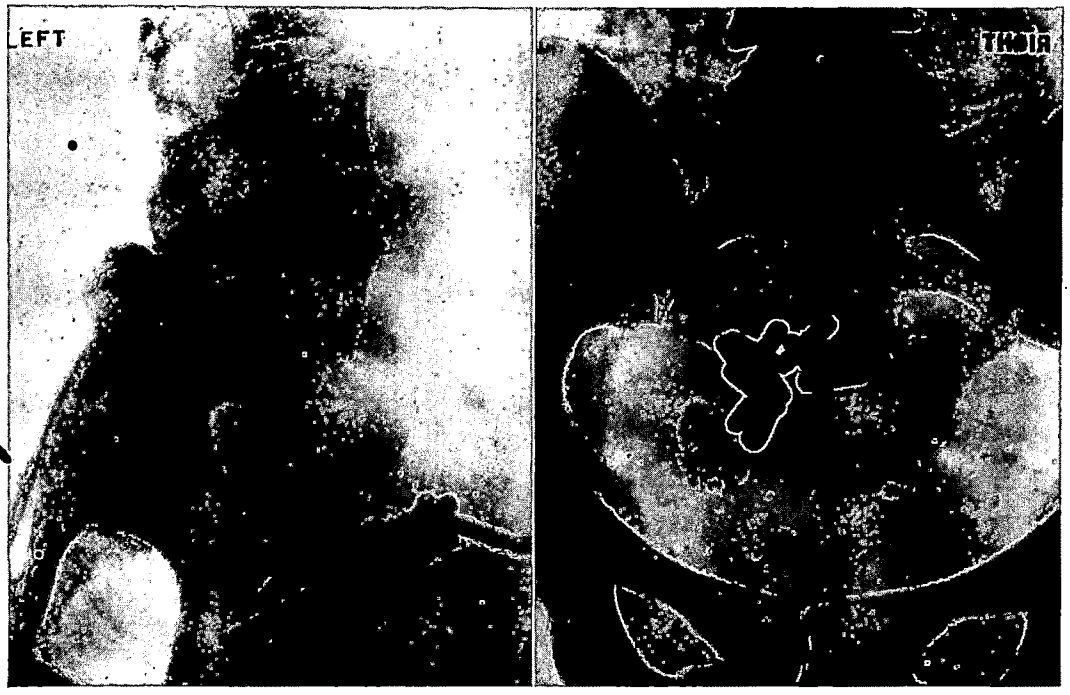


FIG. 11. Roentgenograms showing an atypical arrangement of intra-uterine sources of radium indicating a perforation of the uterine wall.

found. Such instances illustrate clearly the value of roentgenograms taken during each treatment. Perforation of the uterus may present serious complications. It should be noted, however, that only one such injury is known to have occurred in our series of more than 45 cases of corpus cancer treated with multiple capsules. It is to be hoped that some time will elapse before such an accident occurs again, but one cannot expect always to avoid perforation, even in the simplest types of intra-uterine procedure. If in radium treatment there is a greater risk of perforation with multiple capsules, the better irradiation effects obtained by the method would seem to offset the added risk incurred.

Any improvement in clinical results following the addition of irradiation to the treatment of operable patients must be due to an effect upon tumor cells outside the volume of tissue removed surgically. In corpus cancer the point arises immediately as to how often there is apt to be extension outside the uterus itself. This cannot be determined on the basis of the histologic grade of the lesion, and it is impossible to visualize or adequately palpate such extensions. The occasional patient with local recurrence after hysterectomy alone is, however, proof that involvement of those regions does occur. It seems logical, therefore, to employ both irradiation and hysterectomy in all operable patients. At the same time it is difficult to reconcile the use of a large amount of radiation followed promptly by complete removal of the uterus. There can be no doubt that the greater tissue dose obtained outside the uterus by combining roentgen rays with radium before hysterectomy is responsible in part for the relative superiority for preoperative treatment over postoperative roentgen irradiation alone. It should be noted, however, that in most instances the dose falling on tissues outside the uterus is not great. It would seem that there must be other factors responsible for the greater effectiveness of preoperative treatment. An explanation can be attempted upon the

basis of biologic factors. One might expect a greater degree of radiosensitivity before hysterectomy. Following removal of the uterus there is production of fibrosis, interference with vascular supply, and disturbed anatomical relationships. Those factors might contribute to greater radioresistance, and thereby decrease the effectiveness of the relatively small amounts of postoperative radiation falling on regions not removed surgically. It would not seem that hysterectomy would interfere materially with the effect of radiation already applied to the outlying tissues. In fact the reverse might be true, in that the results from surgery actually augment the effectiveness of the previous treatment.

In planning preoperative treatment the use of both roentgen rays and radium is to be recommended. The greater tumor dose obtained by a combination of the two methods is not the only indication for following such a program. For corpus cancer there are advantages gained in beginning treatment with roentgen rays that are identical in some respects to those noted in cervical carcinomas. Infection present in the lesion is decreased by preliminary roentgen irradiation. As a result of the decrease in infection there is less risk of necrosis from radium, and possibly a more favorable degree of radiosensitivity. In addition the effects of roentgen irradiation should lessen the risk of perforation in the more infiltrating types of lesions, and decrease the risk of radium capsules acting as pistons to force viable cancer cells through the lumina of the tubes in all cases.

It is obvious that any advance in methods of treatment for corpus cancer will improve clinical results not only in operable patients, but also in those unsuited to hysterectomy. So far as radium treatment is concerned, therefore, it can be said we are faced with a double responsibility. It is first necessary to devise a technique of treatment that will deliver a more practical distribution of radiation than that which is obtained from the usual intra-uterine tandem. By that means one may expect an improvement in results among cases not suited to hysterectomy due to advanced involvement or some associated constitutional disorder. The second responsibility rests upon the more widespread application of improved radium technique to operable cases.

SUMMARY AND CONCLUSIONS

In 1938 the attempt was made to improve the effectiveness of radium treatment employed for cancer of the corpus uteri at the Barnard Free Skin and Cancer Hospital, and on the teaching service of the Barnes Hospital. A technique employing multiple sources of radium within the uterus was employed. Several modifications have been made in the attempt to simulate the method employed by Heyman. The technique is described, but sufficient time has not elapsed to permit a statistical summary upon the results obtained. The number of patients treated is believed adequate, however, for a preliminary report upon the method in use.

Each case has been studied by means of roentgenograms taken while radium was in situ. The effect of irradiation upon the local lesion has been studied in gross specimens obtained at hysterectomy, or by curettement, whenever possible, in cases not suited to surgery. A marked decrease in the incidence of persistent carcinoma is noted for the multiple capsule technique in comparison with patients treated in the same clinics with an intra-uterine tandem containing radium. For the multiple-capsule method there has been an increase in the total amount of radiation employed, but a marked decrease in the dose contributed by each individual source. As a result there has been a lesser amount of necrosis and other sequelae.

The presence or absence of persistent cancer in a previously irradiated uterus cannot be interpreted as an accurate index of the end-result to be expected. Due to the marked improvement in irradiation effect noted for multiple capsules, however, it is believed that an improvement in clinical results is to be expected.

The value of preoperative irradiation is discussed, and for operable cases it is recommended that hysterectomy be preceded by preliminary roentgen irradiation and radium applied within the uterus. A multiple-capsule technique is advocated for the intra-uterine radium treatment of both operable and inoperable patients. The uterus is known to have been perforated in one instance. Experience with that patient is described briefly.

REFERENCES

1. ARNESON, A. N. Clinical results and histologic changes following the radiation treatment of cancer of the corpus uteri. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 461–476.
2. ARNESON, A. N., and HAUPTMAN, H. Radiation in the treatment of carcinoma of the body of the uterus. *J. Am. M. Ass.*, 1941, *116*, 29–33.
3. ARNESON, A. N., and STEWART, F. W. Clinical and histologic changes produced in carcinoma of the cervix by different amounts of roentgen radiation. *Arch. Surg.*, 1935, *31*, 542–567.
4. BROWN, W. L. Multiple-area intra-uterine irradiation; preliminary report. *J. Am. M. Ass.*, 1930, *94*, 1471–1475.
5. CROSSEN, H. S. Advances in the treatment of cancer of the corpus uteri. *J. Missouri Med. Ass.*, 1940, *37*, 376–386.
6. DONOVAN, M. S., and WARREN, S. Persistence of tumor after preoperative radium treatment for cancer of the corpus uteri. *Surg., Gynec. & Obst.*, 1942, *74*, 1106–1111.
7. FRIEDMAN, M. Treatment of carcinoma of corpus uteri; description of a new hysterostat. *Radiology*, 1940, *35*, 28–35.
8. HEALY, W. P., and BROWN, R. L. Experience with surgical and radiation therapy in cancer of the corpus uteri. *Am. J. Obst. & Gynec.*, 1939, *38*, 1–13.
9. HEYMAN, J. Radiumhemmet method of treatment and results in cancer of the corpus of the uterus. *J. Obst. & Gynaec. Brit. Emp.*, 1936, *43*, 655–666.
10. HEYMAN, J., REUTERWALL, O., and BENNER, S. Radiumhemmet experience with radiotherapy in cancer of corpus of the uterus. *Acta radiol.*, 1941, *22*, 11–98.
11. KAPLAN, I. I. Radiation in cancer of the corpus uteri. *Radiology*, 1942, *39*, 135–143.
12. MARTIN, C. L. Radiation therapy in carcinoma of the fundus of the uterus. *South. M. J.*, 1940, *33*, 135–144.
13. MORTON, D. G. Adenocarcinoma of uterine fundus. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *41*, 789–797.
14. PFAHLER, G. E. New method for application of radium within uterine cavity, with particular reference to carcinoma of the fundus. *Pennsylvania Med. J.*, 1941, *44*, 1118–1123.
15. SAMPSON, J. A. Limitations and dangers of intra-uterine application of radium in treatment of carcinoma of body of the uterus. *Am. J. Obst. & Gynec.*, 1934, *28*, 783–823.
16. SCHMITZ, H., and SCHMITZ, H. E. Improved technique for radium treatment of carcinoma of uterine body. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *34*, 759–765.
17. STRAUSS, H. Treatment of corporeal carcinoma with radium. *New York State J. Med.*, 1940, *40*, 529–534.

DISCUSSION OF PAPERS BY DRS. BOWING AND FRICKE, MARTIN, AND NOLAN AND ARNESON

DR. MAURICE LENZ, New York. Drs. Bowing and Fricke have shown that prognosis in cancer of the fundus and cervix depends on the clinical stage of the cancer, at the time of treatment. Results of hysterectomy, the use of which is limited to Stages I and II, therefore cannot be compared with the results of radiotherapy, which, besides Stages I and II includes Stages III and IV.

In radiation treatment of cancer of the cervix, the clinical stage was practically the only factor which determined the outcome of the treatment. In irradiated cancer of the fundus, on the other hand, microscopic grading also influenced prognosis. In this connection, it should be borne in mind that clinical classification, as to the extent of the tumor, is less accurate in cancer of the fundus than in cancer of the cervix. In cancer of the fundus, therefore, it is more likely that more of clinical Stage IV cancers will be mistakenly classified as less extensive stages, than in cancer of the cervix. The majority of the extensive fundus cancers probably fit into the less differentiated groups. The same may be said of the cervix. Intensive and more adequate irradiation of the entire pelvis, however, is more commonly carried out in cancer of the cervix than in cancer of the fundus. The grave influence of anaplasia in cancer of the cervix is illustrated by the surgical results in this disease.

Dr. Martin has emphasized the importance of avoiding over-irradiation of the intestine and bladder when irradiating cancer of the cervix. In addition to burns due to gross physical causes, such as overcrossing of roentgen-ray beams and misplacement of radium tubes,

there may be physiological reasons for injuries of adjacent structures, as e.g., when seeds or needles are repeatedly inserted into poorly vascularized vaginal septa or when a large amount of roentgen radiation or radium is administered in a short time; the rectum and bladder do not support intensive short treatment as readily as when the same quantity of radiation is delivered in a longer period of time. The report of the Standardization Committee of the American Radium Society in 1937 called special attention to this possible source of injury, basing its conclusions on a survey of 2,855 radiation treated cancers of the cervix. As a result of this survey, the period of the intracavitary radium therapy at the Presbyterian Hospital, New York, was raised from forty to one hundred hours, and the period of the roentgen treatments was lengthened from twenty to forty or even sixty days, while retaining the same total radiation doses. Since then, practically no bladder or intestinal injuries have been seen at the Presbyterian Hospital.

In spite of the danger of irradiation injury in radiotherapy of cancer of the cervix, the importance of roentgen treatment should not be underestimated, even in cases which clinically are classified as Stages I and II. Clinical determination of the extent of the cancer is not very accurate, and intracavitary radium does not adequately irradiate silent parametrial extensions and regional lymph node metastases. While the roentgen-ray dosage which may be administered safely is probably sufficient only to restrain such growths and not to destroy them, even this effect may prolong life.

Drs. Arneson and Nolan clearly demonstrated that in the radium treatment of cancer of the fundus in large uteri, Heyman's method of filling the uterus with multiple radium tubes is superior to the use of single, "Y" shaped, or triple, radium-containing applicators. Adequate intra-uterine irradiation in fundus cancer is important especially in very fat women, as in them it is difficult to deliver a satisfactory depth dose with external 200 kv. roentgen therapy.

DR. MILTON FRIEDMAN, New York. I would like to discuss two points: first, there is no question that in the treatment of carcinoma of the cervix the addition of roentgen therapy to radium therapy improves the results. Under certain ideal circumstances (a radiosensitive tumor in a thin patient), the daily tumor dose and the total dose may be such that roentgen therapy alone can eradicate the tumor.

Under different circumstances, pre-radium roentgen therapy can unfavorably affect the outcome. In obese patients, the daily tumor dose is inadequately small, being in the neighborhood of 100 r. When such irradiation is carried on for four or five weeks, and then another week or two elapses while the patient is being admitted to the hospital and prepared for operation, there may be a total lapse of time of five to seven weeks between the first roentgen treatment and the radium insertion. As a result, only the more radiosensitive tumor cells are destroyed; the remaining cells mature and become more radioresistant; the tumor bed becomes more fibrous and less vascular; and consequently it becomes necessary to administer a very large dose of radium to a tumor which is now more radioresistant, and which lies in a tumor bed that is now less tolerant to radiation. This was strikingly illustrated in a series of patients who received preliminary roentgen therapy of 3,000 to 4,000 r to each of four skin portals over a period of five weeks, and then 7,000 to 8,000 mg-hr. radium (Curie technique). To our amazement, one-fourth of the patients developed local recurrences in the cervix itself.

The solution is varied, depending upon the radiosensitivity of the tumor, the skin-tumor distance, and the daily tumor dose. The arrest of carcinoma of the cervix is accomplished essentially with radium. Roentgen therapy is an adjuvant which offers variable though limited assistance.

Another point: There appear to be as many corpus carcinoma radium gadgeteers as there are military armchair strategists. The principles of multiple foci of radium, and flexibility of their dispersion are essential. When multiple tubes are used, it is necessary to fix them in position, otherwise they will drop to the dependent part of the uterus, and will leave the fundus and upper corpus under-irradiated. At least one tube should rest broadside against the fundus. Little radiation comes from the end of a radium tube. Several tandems situated more or less vertically in the uterus will not effectively irradiate the fundus and the cornua.

DR. BOWING (closing). As to Dr. Lenz's reference to the statistical phase of my paper, I am sorry that I do not feel qualified to enter upon a worthwhile discussion of the probable values contained in statistical data, and the

best or most suitable method of calculating the end-results in the treatment of cancer of the uterus. I am most certain the Division of Biometry and Medical Statistics at the Mayo Clinic would be glad to provide a discussion of our methods of calculation and presentation of statistical material. I shall be pleased to help in every way I can.

The point which Dr. Lenz wishes to make in his statement that all Grade 4 lesions, if studied would be found to be inoperable because of their extent alone is not clear to me. In the main, his statement is acceptable; however, it seems possible that in some cases a lesion of Stage I or II could have a Grade 4 pathologic change or category. In other words, Dr. Broders' early studies concerning the estimation of grade were carried out on surgical material. When grade alone was considered, 90 per cent of those patients who had Grade 4 lesions did poorly after surgical intervention. Studies are in progress which will show the relationship between grade and stage of involvement and the surgical results obtained.

The influence of the age of the patient and the grade of the lesion is of interest. On the basis of our limited studies of cases of cancer of the uterine cervix, we may conclude that age does not affect grade in that the young adult patient may have malignant lesions of any one of the four grades. There seems to be no predominance of particular observations in the group studied.

The point I wish to emphasize is that the gross characteristics and extent of a lesion of the uterine cervix are, in the main, the deciding factors governing the initial application of radium. In other words, the treatment is not administered with only the grade of the lesion as the determining factor. Furthermore, it is important to space applications of radium so that local necrosis or enhancement of the local necrosis already present will be avoided, and so that regional and systemic reactions will be reduced to a minimum. In brief, the importance of individualized radium therapy is recognized.

We rather expected the results obtained in the treatment of cancer of the body of the uterus, because the radium treatment of that particular condition can be classed as a standard technique, devoid of many valuable individual factors. Therefore, our results should be rather uniform for comparisons.

Dr. Friedman mentioned the fact that many different types of radium applicators have been designed for intra-uterine treatment, although my experience with the various types is rather small. Yet, I am of the opinion that as a rule they all possess common factors governing their limitations in intra-uterine treatment.

In answer to the inquiry concerning the use of preliminary roentgen treatment in our cases of cancer of the uterine cervix, I can say that we do not employ this method routinely. We do have in our files records of a small number of patients so treated, as well as records of a larger number of patients who came to our section for further consideration after preliminary roentgen treatment had been administered elsewhere. On the basis of these observations and our own experience, we believe that the rather prompt beneficial response obtained by the initial application of radium produces a superior early result, and that, also, the economic or time factor involved in the technique of preliminary roentgen treatment is greater than it is in our procedure of initial radium therapy followed by supplemental roentgen therapy. I feel rather certain that there is as yet no substitute for the well-planned technique of initial treatment with radium for patients who have cancer of the uterine cervix.

I agree with Dr. Martin's statement that maintenance of the integrity of the tissues which compose the tumor bed is very essential for satisfactory early and late results of treatment. The selection of the proper treatment factors for each patient will make the convalescence shorter and reduce to a minimum the probable late, painful and disabling sequelae. This feature of any technique of treatment is worthy of all possible attention.

Preoperative irradiation was also mentioned. This is a very interesting method of treatment and is deserving of consideration. Briefly, preoperative treatment is applied today in a very limited way. The few patients we have treated were treated by various techniques. Satisfactory statistical studies are not available. Evidently, some definite good can be expected from the procedure. A suitable preoperative technique remains to be established. Certain features seem important. For example, (1) the treatment should be administered with the thought in mind that other therapeutic procedures will follow; (2) the time allowed between this type of treatment and surgical intervention should be sufficient to permit the

utmost good to result from the therapeutic effects and to permit tissue reactions to subside, and this interval probably is a matter of weeks or in some cases months, and (3) it should not be expected that inoperable lesions will be made operable by means of preoperative treatment. In the future this method of treatment may become more favored than it is today. In some communities an economic factor may limit general acceptance of it.

Dr. Martin (closing). I wish to thank Dr. Lenz for his excellent discussion and to apologize for not stressing his report made in 1937. Apparently his experience more or less parallels ours. The numerous reports of serious injuries which have appeared in medical journals during the past few years indicate that his work has been disregarded in many quarters.

I will be much interested in his final survival rate in Stage III cases treated with his intensive roentgen-ray technique without serious sequelae. Most of the reports which I have studied have not shown enough improvement in five year survival rate from the more intensive techniques to convince me that the increased danger to normal structures is justifiable.

Dr. Lenz stated that intensive preliminary roentgen therapy makes the application of radium easier. In our experience such has not been the case. This is probably due to the fact that we like to use large radium spools in the vaginal vaults and the shrinkage resulting from the roentgen irradiation makes their proper application practically impossible.

In going over the literature I have been unable to find any accurate experimental data covering the exact tolerance doses for the normal structures in the pelvis under standard treatment conditions. In my opinion, some of the research departments in our large institutions should be put to work on this important problem.

Since I also have devised a radium applicator for the treatment of cancer of the uterine fundus, I cannot resist the temptation to discuss that subject. The multiple capsules advocated by Heyman are only effective when they are kept well up in the top of the uterus in intimate contact with the malignant tissue. If they are held in place by a pack, drainage is interfered with and when they are not packed in position they tend to fall away from the tumor. Each of our capsules is attached to a short wire by a hinge. A loop on the lower end of each wire protrudes through the external os and when the fundus is filled with capsules drainage is maintained along the wires which insure their being held in the proper position. The hinges allow the capsules to be maneuvered into uterine cavities of various shapes and sizes. It seems reasonable to assume that Dr. Healy's prognostic sign, namely, the size of the uterus may no longer be so important when the larger tumors are more efficiently irradiated.

VOL. 49, NO. 4

CANCER OF THE CERVIX

THE EFFECT ON THE RATE OF CURE OF INCREASED ROENTGEN RADIATION TO THE PARAMETRIA*

By WILLIAM P. HEALY, M.D., *and* GRAY H. TWOMBLY, M.D.
From the Memorial Hospital
NEW YORK, NEW YORK

IN THE six years from 1932 to 1937, nine hundred and twenty cases of primary cancer of the cervix were seen in the gynecological department of the Memorial Hospital. This total is large. The patients have been seen and treated by a few men. During this period the method of giving radium has been practically constant while several different schemes of giving external roentgen therapy have been used. Consequently, this group of cases offers an almost ideal set of statistics for an inquiry into the question of what value roentgen therapy may have in the treatment of cancer of the cervix and what form of roentgen therapy appears to be the most effective.

In 1931 Healy[4] reviewed the results of treatment of 1,574 cases of carcinoma of the cervix at the Memorial Hospital. This included all cases seen and treated from 1918 up to 1931. During this period the treatment given consisted of a vaginal bomb for 1,000–3,000 mc-hr. with a filtration of 2 mm. of brass, and an application of radium to the cervical canal of 1,500 to 3,000 mc-hr. filtered with 0.5 mm. of platinum or gold and 1 mm. of rubber. In addition, from 1918 to 1925, unfiltered glass radon seeds for 200 to 2,000 mc-hr. were inserted into the cervix. In 1925 these were replaced with gold seeds, 0.3 mm. in wall thickness.

External irradiation was given from 1918 to 1921 with radium in an external pack in six positions around the pelvis. The radium was held on a brass and bakelite block 4 cm. away from the skin and a total dose of 9,000 to 18,000 mc-hr. given. In 1922 this was replaced by low voltage roentgen radiation with 4 mm. of aluminum filtration delivered at a target-skin distance of .30 cm.; 140 kv. (peak). Sixty ma-min. or about 400 r were delivered to each of four fields. The roentgen as a unit of roentgen-ray measurement had not been established at this time. This dose is estimated on the basis of the skin reactions usually observed. In 1926 this type of treatment was replaced by high voltage roentgen therapy.

As we know now, the amount of radiation delivered to the cervix or parametria by the external radiation therapy used from 1918 to 1926 was not very large. Consequently, the five year cure rate reported by Healy of 22.5 per cent represents what may be expected by the application of radium alone to the cervix as we have continued to use it, for the dose of radium used in our cases up to and including 1937 is essentially unchanged from that reported in this paper of Healy's.

In 1937 Healy and Frazell[7] reported the results of treatment of 551 cases of primary carcinoma of the cervix seen during the years 1928 to 1931, inclusive. These patients were treated first with high voltage external roentgen therapy delivered through four 10 by 15 cm. pelvic portals. The daily dose was 750 r to one field. The physical factors were 200 kv. (peak), 4 or 30 ma., 50 cm. target-skin distance, and 0.5 mm. Cu filtration. Within a week or ten days following the last roentgen treatment, a radium treatment of 1,500 mc-hr. was given directly against the cervix by means of a vaginal applicator or "bomb." The following day an intracervical and intra-uterine application of radium of 3,000 mc-hr. was made with two capsules, the filtration of which was 0.5 mm. platinum and 1 mm. rubber.

The five year survival rate for this

* Presented at the Twenty-seventh Annual Meeting, American Radium Society, Atlantic City, N. J., June 8–9, 1942.

method of treatment in this group of cases was found to be 27.7 per cent. These figures suggest that the addition of more efficient high voltage external roentgen therapy previous to the local application of radium had raised the cure rate approximately 23 per cent.

In 1934 Arneson and Quimby[2] reported a study of the distribution of roentgen radiation within the female pelvis for different physical factors of irradiation. They concluded that the use of six pelvic fields, each 10 by 15 cm. (two anterior, two posterior, and one on each lateral surface) with a target-skin distance of 70 cm. was the most desirable of the methods they investigated for giving external irradiation in cancer of the cervix. While this report was published in 1935, the studies which led up to it had been made several years previously and the treatment in favorable cases in our clinic had been changed in 1933 by using six fields, increasing the distance to 70 cm. and giving daily doses to each of two fields of 200 r. The total dose per field was 2,000 to 2,400 r. Again the physical factors were 200 kv. (peak), 30 ma. current, 0.5 mm. Cu and 2 mm. Al filtration. This treatment took three to four weeks to complete. It was estimated that it delivered 3 to 5 threshold erythema doses to the parametria for a distance of 10 to 11 cm. lateral to the cervical canal. This method of treating patients was reported first by Healy and Arneson[6] in September, 1933 (see Fig. 1).

In 1935 Healy[5] made a preliminary report on 107 patients who had been so treated. He found skin reactions and intestinal disturbances more marked than with single doses of 700 r to each of six fields. Rarely were the skin reactions severe enough to force the stopping or postponing of the treatment, but occasionally the symptoms of large bowel irritation did so. Bladder symptoms were found to be mild. The immediate healing observed in the cervix and the marked regressive changes observed microscopically in the tumor, while not complete, were exceedingly encouraging.

This method of treating cancer of the cervix was continued for several years and will be referred to as "divided dose technique" in this paper. It was used routinely on clinic patients from 1933 to 1936 when the patient lived near the hospital so that daily visits were practical for her.

In private cases, largely for economic reasons, treatment through four or six pelvic portals with doses of 700 to 750 r to each portal were continued throughout this period. Patients living at a distance were also so treated. This method will be referred to as "massive dose technique."

It should be noted, as shown in Figure 1, that the total amount of roentgen radiation delivered to the parametria in the "divided dose" type of treatment is much greater than that given by the "massive dose" type. The tissues lying next to the walls of the pelvis receive less than one threshold erythema dose of radiation when a radium bomb and tandem alone are used. With the "massive dose" type of treatment these tissues receive 0.8 to 2 threshold erythema doses. When the "divided dose" technique is used and 12×200 r (2,400 r) is delivered at 70 cm. to each of six fields, the same areas receive 4 to 7 threshold erythema doses. Of course, it must be remembered that "massive dose" technique requires only a week or less to deliver the full dose, while "divided dose" therapy usually requires thirty-six treatment days or six weeks. Thus, the increase in dose to the parametria is probably less than arithmetical if one considers the factor of biological recovery taking place in such a treatment interval.

In his report in 1935 Healy[5] notes observations made by Stewart on multiple biopsies taken from the cervix during the course of "divided dose" roentgen therapy. Stewart felt that in some instances the later biopsies showed a slowing up in irradiation effect on the cancer cells after a week or ten days of treatment. Following this lead 14 cases were treated through four portals giving 200 r×5 to each portal, or a total of 1,000 r, and then increasing the daily

dose to 300 r for five additional treatments to each portal. This gave a total dose of 2,500 r. Two cases were given 200 r for one cycle, 300 r for four cycles, and 400 r for three cycles, or 2,600 r per portal. Another method followed in some cases was to give 200 r×5 to each portal and follow with 250 r×2 or a total of 1,500 r to each of six portals. The groups so treated were small and all are included under the heading "divided dose technique."

In 1936, following the suggestions of Stewart about the apparent increasing radioresistance of cervical cancer during the course of roentgen therapy, a new technique was adopted and has been used on all ambulatory clinic cases living near the hospital up to the present time. This we will refer to as "pyramidal dose technique." It consists in treating the patient through six pelvic portals, each 10 by 15 cm., two anterior, two posterior, and one on each side. The factors are 200 kv. (peak), 0.5 mm. Cu filter, 30 ma. current, and 70 cm. target-skin distance. Two opposite portals are treated daily. These receive 100 r the first day. Two more receive 100 r the next day, and the last two 100 r on the third day. On the fourth day the first two portals receive 150 r, and so on. The third

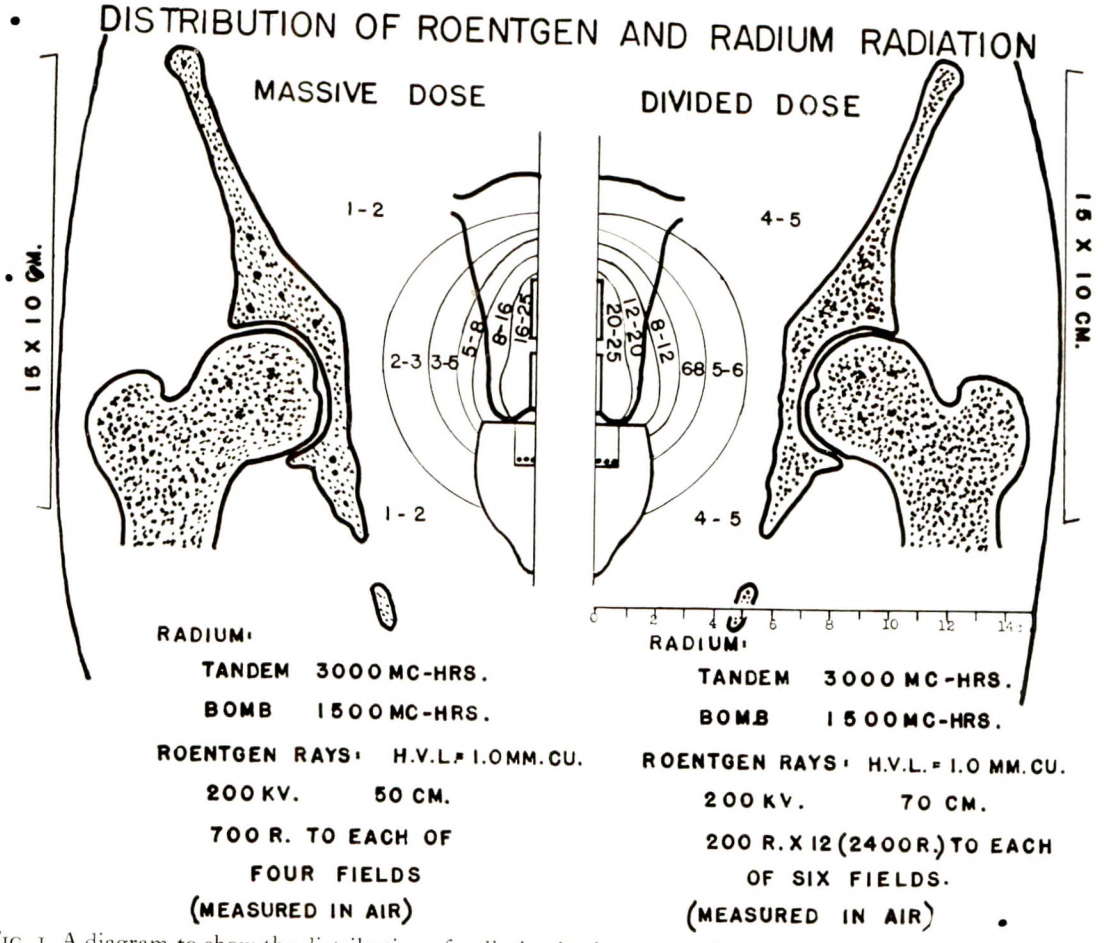


FIG. 1. A diagram to show the distribution of radiation in the average female pelvis when the radium dosage is kept constant (bomb with 1,500 mc-hr. Tandem = 2,000 mc-hr. in the lower capsule, 1,000 mc-hr. in the upper capsule) and the external roentgen therapy is varied. It should be noted that "massive dose" as pictured would take four days to deliver; "divided dose," thirty-six days, and this time interval is of biological importance (data for diagram taken from Arneson).[1]

cycle is 200 r per portal; the fourth, 250 r; the fifth, 300 r; the sixth, 350 r; and the seventh, 350 r. This totals 1,700 r per portal. This amount of roentgen radiation, with the factors given, seems, in the majority of the patients so treated, to represent the maximum dosage that the normal tissues in the irradiated fields can withstand. Moreover, at this dosage level many patients are inclined to develop marked digestive and intestinal disturbances. The entire treatment takes three and a half weeks. Four to six weeks later a vaginal applicator containing radium is inserted for 1,000 to 1,500 mc-hr. and the next day a radium tandem is placed in the cervical canal for 3,000 mc-hr. The filtration is 0.5 mm. platinum and 1 mm. rubber. Two tubes of radon are used, the upper, which goes into the uterine cavity, containing one-half the amount in the lower capsule while lies directly against the cancer in the cervix.

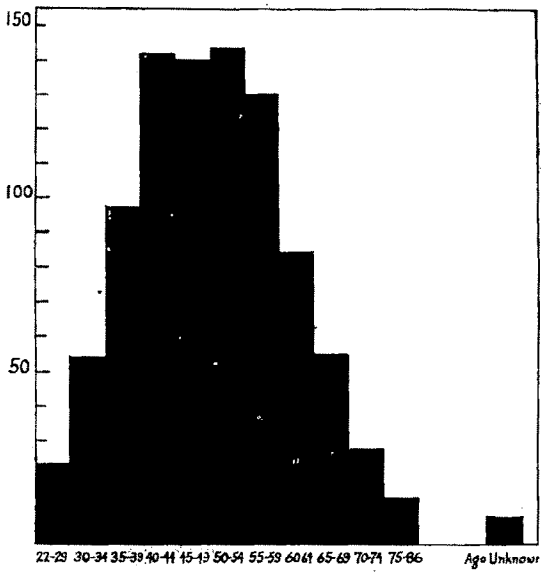


FIG. 2. Age distribution of 920 cases of primary carcinoma of the cervix seen at the Memorial Hospital between 1932 and 1937 inclusive.

As mentioned in our introductory paragraph, this method of applying radium has not changed from 1932 to the present. We have then, a large number of cases receiving the same dose of radium, seen by the same attending physicians, followed with the same care, and drawn from the same population, the only variable being the use of one of three methods of external roentgen therapy, i.e. "massive," "divided," or "pyramidal dose technique."

MATERIAL

During these years 920 cases of primary carcinoma of the cervix have been seen and treated in our clinic. The age distribution is given in Figure 2 which shows the highest incidence to lie between forty-five and forty-nine. Twenty-three cases were under thirty years of age; the youngest, twenty-two; thirteen were over seventy-five, the oldest being eighty-six.

The majority of cases occurred in married women who had borne children. Of the 920 patients, 607 were married and 240 widowed while 42 were separated or divorced. Only 24 were single and of these, 6 admitted that they had been pregnant or borne children. On 7 charts the marital status was not recorded. Thus, only 18 out of 913, or 2 per cent, were even nominally virgins. These figures serve to emphasize once again that cancer of the cervix is a disease of married and usually parous women.

Turning to the nationality of the patients, as indicated by the hospital records, it is found that 417, or 45.3 per cent, were born in the United States. Italians made up the next largest group with 126, or 13.7 per cent. There were 78 Negroes, or 8.5 per cent, 62 Germans, Dutch or Austrians, or 6.7 per cent, and 41 Irish, or 4.4 per cent. In spite of the large Jewish population in New York and the preponderance of Jews in our other clinics, only 46, or 5.0 per cent, were Jewish in this group suffering from cancer of the cervix. This figure is a generous one. There was no way of checking race save by the charts. If a name was Jewish but no special note was made of the patient's racial extraction, she was counted as Jewish. Consequently, the 46 probably include several who do not belong in this group. It is

indeed a striking fact that a maximum of only 5 per cent of the cases of cancer of the cervix occurred in Jewish women, and it is hard to believe that this can be accounted for by any marked difference in sexual hygiene. The occurrence of cancer in the cervix among married women with uncircumcised husbands would seem a fertile field for research into etiological relationships.

The possibility that the kind of partner may play a larger rôle than the parity of the patients is suggested further when one examines the reproductive histories of our patients. Of 532, in whom complete reproductive histories were recorded, 70, or 13.1 per cent, had never been pregnant. Many had been pregnant a large number of times, however, so that the average number of pregnancies was 4 per patient. The number of viable births in this group averaged 3.03 per patient.

Is there any abnormality about the menstrual history of patients who later develop cancer of the cervix? Our data are not complete, but what we have fail to show any striking features. Of 379 patients, 221 stated that the onset of their menstrual periods was between the ages of thirteen and fifteen. Ninety-four began to menstruate at the age of twelve or younger; 64 at sixteen or older. Of 413 patients, 390 menstruated every twenty-four to thirty-two days; 22 every twenty-three days or less and 1 every thirty-three days or longer.

TABLE I

DURATION OF SYMPTOMS

Length of Time	No. of Cases
Under 2 weeks	21
Between 2 weeks and 1 month	49
1 to 2 months	141
3 to 5 months	228
6 to 11 months	196
12 to 23 months	151
24 to 35 months	56
36 months or more	50
Not stated	28
TOTAL	920

The duration of flow was three to six days in 296 patients. It was prolonged to seven days or more in 54 and was scanty, lasting two days or less, in 19. Thirty-five patients said that ther periods were "irregular."

An attempt was made to determine whether any previous gynecological operations had been performed on many of the

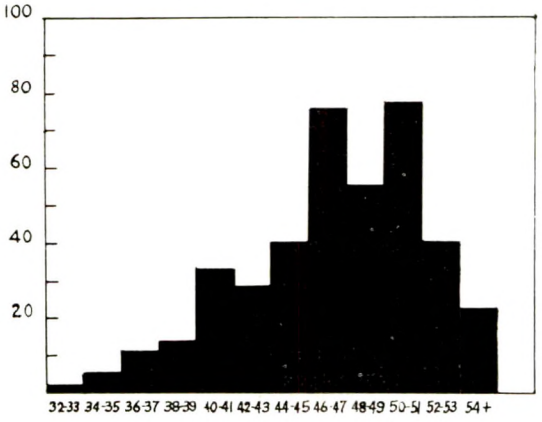


FIG. 3. Age at the menopause of 402 cases of cancer of the cervix.

patients but on this point not much information was recorded on the charts. Thirty-two patients said that they had undergone dilatation and curettage previous to the onset of the present illness. In 1 case the cervix had been cauterized. In 7 it had been repaired. Evidently the last type of operation will not prevent cancer of the cervix in all cases. In 24 patients some type of vaginal plastic operation had been done. Forty-eight had lost one or both ovaries.

In 383 the menopause had not been reached. The age distribution at the menopause in the remaining 402, in which this fact was recorded, is shown in Figure 3 with the highest incidence at forty-six to forty-seven and fifty to fifty-one.

Of course the commonest symptom of cancer of the cervix is bleeding. This was noted as occurring between the periods or after the menopause in 786 instances. Contact bleeding was noted by 138 patients; increased flow at the periods by 141; 449 had vaginal discharge; 331, pain; 294, loss of weight; while 18 had urinary inconti-

nence. In Table 1 is recorded the duration of symptoms. It is to be noted especially that 257 had been aware of some symptom for a year or more before they came to us. This is 27.9 per cent of the whole group. It constitutes an unfavorable commentary on our ability to get early treatment to the patient with this disease.

From these figures it is seen that our entire group of 920 cases are not very different from other groups having cancer

TABLE II

REASONS FOR UNSUITABILITY OF 351 CASES AS MATERIAL FOR THIS STUDY

1. No bomb or tandem used in this hospital	100
2. No bomb	75
3. No tandem	31
4. No primary roentgen therapy in this hospital but orthodox radium treatment	57
5. No primary roentgen therapy or bomb	14
6. No primary roentgen therapy or tandem	6
7. Roentgen therapy only partially completed	3
8. No roentgen or radium therapy in this hospital	40
9. No biopsy obtained	17
10. Patient followed for less than 1 month after completion of treatment	2
11. Mixed forms of roentgen therapy (i.e., part massive, part divided)	3
12. Radium given in some special manner	2
13. Rare tumor of the cervix—"adenomyosarcoma"	1
TOTAL	351

of the cervix. They emphasize again the points which are already well known, that cancer of the cervix occurs in married women but fails to appear with expected frequency among Jewish women in spite of their varied social and national backgrounds and their frequently high birth rate.

THERAPY

We come now to the main part of this paper, a consideration of the results of different types of external roentgen therapy on the cure rate. In a search of the literature few studies were found in which any such comparison has been made. Schmitz, Schmitz and Sheehan[10] have compared the results they obtained with radium (3,000–4,000 mg-hr.) and 140 kv. roentgen rays (20.8 per cent gross three year cure rate) with a group treated with radium (4,500 mg-hr.) and 200 kv. roentgen rays (29.2 per cent gross three year cure rate) and with a group of 34 treated with 800 kv. roentgen rays (50 per cent gross three year cure rate). A later report by Schmitz and Sheehan[11] records 26 cases treated with 800 kv. roentgen rays and radium with 12 survivors at five years, or 46.1 per cent.

Several authors have published statistics on the improvement in five year cure rates in cancer of the cervix when roentgen therapy was added to the radium treatment previously used. For instance, Smith and Pemberton[12] report a 42 per cent five year cure rate for patients treated with roentgen rays and radium from 1929 to 1933 inclusive, and compare this with 28 per cent cured between 1924 and 1928 by radium or surgery or both. Of 106 cases treated in 1929 to 1933 with radium alone, 30, or 28 per cent, survived at five years, while of 154 cases treated with radium and roentgen radiation in the same years, 65 survived (42 per cent). That this represents a real increase in survival rate is suggested by their gross survival rate of 38 per cent of all cases seen in these later years.

Meigs and Jaffe[8] report a group of 70 cases with 24 showing clinical cure at the end of five years, or 34.4 per cent. This they attribute to external roentgen therapy.

Several papers have appeared in which varying techniques of radium application have been compared, notably papers by Pitts and Waterman,[9] and the League of Nations reports, so ably reviewed and summarized by Swanberg,[13] but with this question we are not concerned in this paper.

With our own cases we have selected for comparison only those cases in which the following criteria were fulfilled:

1. The diagnosis was confirmed by biopsy.
2. The patient was treated with a vaginal applicator for at least 1,000 mc-hr.
3. A tandem of radon capsules was inserted into the cervix.

TABLE III

FIVE YEAR CURE RATES

387 cases seen from 1932 to 1935 inclusive, proved by biopsy, treated by radium and full roentgen therapy and followed after treatment

	League of Nations Classification											
	Total	Per Cent	Stage I	Per Cent	Stage II	Per Cent	Stage III	Per Cent	Stage IV	Per Cent	Undiagnosed	Per Cent
Massive Dose												
Total	288	100	49	17	98	34	126	44	6	2	9	3
Lost under 5 years	18	6.2	3	6.1	8	8.2	5	4	1	16.7	1	11.1
Dead under 5 years cause unknown or cancer	170	59.0	17	34.7	51	52.0	91	72.2	5	83.3	6	66.7
Dead under 5 years without cancer	8	2.8	1	2.0	3	3.0	4	3.2	0	0	0	0
Alive at 5 years without cancer	82	28.5	26	53.2	32	32.7	22	17.4	0	0	2	22.2
Alive at 5 years with cancer	10	3.5	2	4.0	4	4.1	4	3.2	0	0	0	0
Divided Dose												
Total	99	100	12	12	32	32	48	48	0	0	7	7
Lost under 5 years	6	6.1	1	8.3	3	9.4	1	2.1	0	0	1	14.3
Dead under 5 years cause unknown or cancer	51	51.5	3	25.0	12	37.5	33	68.7	0	0	3	42.8
Dead under 5 years without cancer	3	3.0	1	8.3	1	3.1	1	2.1	0	0	0	0
Alive at 5 years without cancer	35	35.4	6	50.0	16	50.0	11	22.9	0	0	3	42.8
Alive at 5 years with cancer	4	4.0	9	8.3	0	0	2	4.2	0	0	0	0

4. Either "massive dose," "divided dose," or "pyramidal dose" technique of roentgen therapy was used. If less than three-quarters of the scheduled treatment was actually delivered, the case was not considered suitable.

5. The case was followed for at least a month after completion of therapy.

When these criteria are applied, of 597 cases seen and treated between 1932 and 1935 inclusive, 288 are suitable as examples of "massive dose technique" and 99 as examples of "divided dose technique." If the 920 cases seen from 1932 to 1937 inclusive are studied and three year cure rates used, 363 are suitable as examples of "massive dose technique," 163 as examples of "divided dose technique," and 43 as examples of "pyramidal dose technique," or a total of 569. The remaining 351 were considered unsuitable for this study for the reasons listed in Table II.

In Table III are given the five year cure rates of the suitable "divided dose" and "massive dose" cases. They are respec-

TABLE IV

THREE YEAR CURE RATES

569 cases seen from 1932 to 1937 inclusive. These cases include all proved by biopsy, treated by vaginal and cervical radium application, and by full roentgen therapy and followed for at least a month after the completion of the treatment

	League of Nations Classification											
	Total	Per Cent	Stage I	Per Cent	Stage II	Per Cent	Stage III	Per Cent	Stage IV	Per Cent	Unclassified	Per Cent
Massive Dose												
Total	363	100	68	18.7	122	33.6	156	43.0	8	2.2	9	2.5
Lost under 3 years	19	5.2	4	5.9	9	7.4	4	2.6	1	12.5	1	11.1
Dead under 3 years cause unknown or cancer	197	54.3	18	26.5	59	48.3	108	69.3	7	87.5	5	55.5
Dead under 3 years without cancer	9	2.5	3	4.4	3	2.5	3	1.9	0	0	0	0
Alive at 3 years without cancer	123	33.9	40	58.9	45	36.9	35	22.4	0	0	3	33.4
Alive at 3 years with cancer	15	4.1	3	4.4	6	4.9	6	3.8	0	0	0	0
Divided Dose												
Total	163	100	18	11.0	52	31.9	81	49.7	0	0	12	7.4
Lost under 3 years	7	4.3	1	5.5	4	7.7	1	1.2	0	0	1	8.4
Dead under 3 years cause unknown or cancer	86	52.7	5	27.8	21	40.4	54	66.7	0	0	6	50.0
Dead under 3 years without cancer	4	2.5	0	0	2	3.8	2	2.5	0	0	0	0
Alive at 3 years without cancer	59	36.1	12	66.7	22	42.3	20	24.7	0	0	5	41.6
Alive at 3 years with cancer	7	4.3	0	0	3	5.8	4	4.9	0	0	0	0
Pyramidal Dose												
Total	43	100	5	11.6	13	30.2	23	53.5	2	4	0	0
Lost under 3 years	1	2.3	0	0	0	0	1	4.4	0	0	0	0
Dead under 3 years cause unknown or cancer	25	58.2	2	40	7	53.8	14	60.9	2	100	0	0
Dead under 3 years without cancer	1	2.3	0	0	1	7.7	0	0	0	0	0	0
Alive at 3 years without cancer	13	30.2	3	60	4	30.8	6	26.1	0	0	0	0
Alive at 3 years with cancer	3	7.0	0	0	1	7.7	2	8.7	0	0	0	0

tively 35.4 per cent and 28.5 per cent.

In Table IV are the three year cure rates for all suitable "divided dose," "massive dose," and "pyramidal dose" cases. They are 36.1 per cent, 33.9 per cent and 30.2 per cent respectively. The three year survival rates are 40.4 per cent for "divided dosage," 38 per cent for "massive dosage," and 37.2 per cent for "pyramidal dosage."

The increase in five year cure rates from 28.5 per cent to 35.4 per cent by changing the method of external roentgen therapy from "massive dose technique" to "divided dose technique" is impressive. Are these differences in end-results real or are they the result of selection of cases? Obviously, if all the favorable cases were treated by "divided dose technique," one would expect a higher cure rate in this group.

In order to answer this question, the entire group was reviewed by one of us, each history being read with great care, and the case assigned to a League of Nations classification irrespective of how it had been originally classified. In this work the diagrams published in "An Atlas Illustrating the Division of Cancer of the Uterine Cervix into Four Stages"[3] published by the League of Nations, were constantly referred to. It is unfortunate that the League of Nations Committee in 1937 changed the basis of its classification, notably by putting cases formerly classified as Stage IV because of fixation into Stage III, reserving for the former group only cases with extension into the bladder or rectum or distant metastases. Because of this change in classification and because of the confusion arising in some minds between the League of Nations system and that proposed by Schmitz, grouping of cases by classes is often not uniform, and it seemed wiser to attempt a reclassification of all our cases by one man on the basis of the clinical description on the history. While admitting the difficulty in deciding on classification by description alone without recourse to examination, nevertheless, when such a classification is done without reference to the type of treatment the patient subsequently received, any errors should be equal in different treatment groups. Such a classification ought to form a fair basis of comparison of one treatment group with another.

The classification of the three suitable groups according to extent of disease is recorded in Tables III and IV. An inspection of these tables shows that of the "massive dose" cases in the five year group, 17 per cent were in Stage I, 34 per cent in Stage II, 44 per cent in Stage III and 2 per cent in Stage IV, with 3 per cent not classifiable. Of the "divided dose" cases, 12 per cent were in Stage I, 32 per cent in Stage II, 43 per cent in Stage III, and none in Stage IV; 7 per cent were not classifiable. Thus 5 per cent more of the "massive dose" cases fell into the early or operable group than did the "divided dose" cases. Similarly, when we examine Table IV covering all suitable cases from 1932 to 1937 inclusive, we find 18.7 per cent of the "massive dose" cases in Stage I, 33.6 per cent in Stage II, 43 per cent in Stage III, and 2.2 per cent in Stage IV, and 2.5 per cent unclassified. Of the "divided dose" cases, 11.0 per cent are in Stage I, 31.9 per cent in Stage II, 49.7 per cent in Stage III, none in Stage IV, and 7.4 per cent unclassified. Of the "pyramidal dose" cases, 11.6 per cent are in Stage I, 30.2 per cent in Stage II, 53.5 per cent in Stage III, and 4.7 per cent in Stage IV.

Of all suitable cases, 15.9 per cent are in Stage I, 32.9 per cent in Stage II, 45.7 per cent in Stage III, and 1.8 per cent in Stage IV. If we correct by these figures our cure rate for each treatment group, we find the corrected five year cure rate to be 28.1 per cent for the "massive dose technique," and 36.8 per cent for the "divided dose technique," while the three year cure rate is 33 per cent for the cases treated by "massive dose technique," 37.2 per cent for the "divided dose" cases, and 31.6 per cent for the "pyramidal dose" cases. Thus the observed differences in cure rates for various forms of roentgen therapy are *not* dependent on selection of cases by extent of disease. Rather were the less

TABLE V

BIOPSY CLASSIFICATION—MASSIVE DOSE

	Squamous Carcinoma						Adeno-carcinoma		Adeno-canthoma		Not Graded	
	Grade 1	Per Cent	Grade 2	Per Cent	Grade 3	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Total	16	6	222	77	30	10	4	1	3	1	12	4
Lost	2	12.5	15	6.8	1	3.5	0	0	0	0	0	0
Died with cancer or?	6	37.5	135	60.8	21	70.0	1	25	1	33.3	5	41.7
Died without cancer	0	0	5	2.3	1	3.3	1	25	1	33.3	0	0
Living at 5 yr. without disease	8	50.0	62	27.9	6	20.0	2	50	1	33.3	5	50
Living at 5 yr. with disease	0	0	5	2.3	1	3.3	0	0	0	0	1	8.3

BIOPSY CLASSIFICATION—DIVIDED DOSE

	Squamous Carcinoma						Adeno-carcinoma		Adeno-canthoma		Not Graded	
	Grade 1	Per Cent	Grade 2	Per Cent	Grade 3	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Total	3	3	80	80	9	9	3	3	2	2	2	2
Lost	1	33.3	5	6.3	0	0	0	0	0	0	0	0
Died with cancer or?	1	33.3	41	51.0	4	44.5	2	66.6	2	100	1	50
Died without cancer	0	0	3	3.8	0	0	0	0	0	0	0	0
Living at 5 yr. without disease	1	33.3	28	35	5	55.5	1	33.3	0	0	1	50
Living at 5 yr. with disease	0	0	3	3.8	0	0	0	0	0	0	0	0

favorable cases treated by the more successful "divided dose" type of therapy.

Can the apparent superiority of the "divided dose technique" be explained on the basis of the age distribution of the patients in the treatment groups? In general, the older patients were treated by "massive dose," since this entailed fewer visits to the hospital and less physical effort. For instance, between 1932 and 1935, 47 per cent of the patients receiving "massive dose" therapy were under fifty and 53 per cent were fifty or over, while 65 per cent of the patients receiving "divided dose" therapy were under fifty and 35 per cent over fifty. How little significance this has is seen when it is pointed out that of all suitable cases treated over five years ago those over fifty showed a higher five year survival rate, 36 per cent, than did those under fifty, 32 per cent. That is, the older patients treated by "massive dose technique" really constituted the more favorable cases. In spite of this they did not do so well as the younger patients receiving "divided dose technique." If we correct for age distribution in the two groups, we find a 31.9 per cent five year cure rate for "massive dose"

therapy and a 39.4 per cent cure rate for "divided dose" therapy.

Finally, is it possible that the difference in cure rate for massive and divided dose therapy can be explained on the basis of histopathological classification of cases? Is it possible that the more slowly growing and perhaps more favorable histopathological types of tumors were treated more by one technique than the other, therefore give a better cure rate for that technique? In Table v is seen the classification of the 386 suitable cases by biopsy report. It is noted that in the group treated by "massive dose technique" 6 per cent were in Grade 1 with a 50 per cent cure rate, 77 per cent in Grade 2 with a 27.9 per cent cure rate, and 10 per cent in Grade 3 with a 20 per cent cure rate. In the "divided dose" group, 3 per cent were in Grade 1 with 33 per cent cures, 80 per cent in Grade 2 with 35 per cent cures, and 9 per cent in Grade 3 with 55.5 per cent cures. If this inequality of histopathological picture be corrected for again the difference in five year cure rate between the two groups is made more rather than less marked, 29.5 per cent for "massive dose" and 37.7 per cent for "divided dose."

In brief, then, in our clinic comparable groups of cases treated exactly the same except for the type of external roentgen therapy received show that the so-called "divided dose technique" gave a 35.4 per cent five year cure rate, while "massive dose technique" gave 28.5 per cent. These differences are made more marked rather than less if the statistics are corrected for extent of disease in the two groups, age distribution, or histopathological classification. That the difference in cure rates is real is further suggested by larger numbers of cases followed only three years in which again a decided increase in cure rate is seen in those receiving the "divided dose" therapy.

SUMMARY

1. Nine hundred and twenty cases of primary carcinoma of the cervix observed in Memorial Hospital from 1932 to 1937 inclusive are reported and reviewed.

2. The peak in age incidence in this group lay between forty and fifty-five.

3. Only 24 of the 920 cases were single and of these 6 admitted that they had borne children.

4. Of foreign born patients, Italians showed the highest incidence of cervical cancer.

5. Negroes formed 8.5 per cent of the group.

6. Only 46, or 5 per cent, of the cases were Jewish, in spite of the large number of Jews in the population of New York City.

7. When the same kind and amount of radium was given to patients treated by different types of external roentgen therapy, it was found that a 28.5 per cent five year cure rate followed the so-called "massive dose technique," while 35.4 per cent followed the "divided dose technique." This difference was not due, as far as could be determined, to the extent of the disease in the patients making up the two groups, the age of the patients, or the histopathological grades of tumor found to be present.

REFERENCES

1. ARNESON, A. N. Distribution of radiation within the average female pelvis for different methods of applying radium to the cervix. *Radiology*, 1936, *27*, 1–20.
2. ARNESON, A. N., and QUIMBY, E. H. Distribution of roentgen radiation within the average female pelvis for different physical factors of irradiation. *Radiology*, 1935, *25*, 182–197.
3. Atlas Illustrating the Division of Cancer of the Uterine Cervix into Four Stages according to the Anatomical and Clinical Extent of the Growth. League of Nations Health Organization. P. A. Norstedt and Sons, Stockholm, 1938.
4. HEALY, W. P. Carcinoma of cervix uteri; report of 1574 cases. *J. Am. M. Ass.*, 1931, *97*, 1680–1683.
5. HEALY, W. P. Experience with multiple dose roentgen therapy in malignant diseases of uterus and ovaries. *Am. J. Obst. & Gynec.*, 1935, *30*, 613–624.
6. HEALY, W. P., and ARNESON, A. N. Radiation treatment of carcinoma of cervix. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 646–653.

7. Healy, W. P., and Frazell, E. L. Methods and results of treatment in carcinoma of cervix at Memorial Hospital. *Am. J. Obst. & Gynec.*, 1937, *34*, 593–606.
8. Meigs, J. V., and Jaffe, H. L. Carcinoma of cervix treated by roentgen-ray and radium. *Surg., Gynec. & Obst.*, 1939, *69*, 257–266.
9. Pitts, H. C., and Waterman, G. B. Treatment of cancer of cervix uteri at Rhode Island Hospital; report of 293 cases with 5 year follow-up. *Surg., Gynec. & Obst.*, 1937, *64*, 30–38.
10. Schmitz, H., Schmitz, H. E., and Sheehan, J. F. Clinical observations on treatment of primary carcinomata of cervix with 800 kv. roentgen rays. *Am. J. Obst. & Gynec.*, 1938, *35*, 405–417.
11. Schmitz, H. E., and Sheehan, J. F. Five year end-results in cervical carcinoma treated with radium and 800 kilovolt roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 229–234.
12. Smith, G. V., and Pemberton, F. A. Carcinoma of uterine cervix; results of treatment through 1933, showing value of supplementary x-radiation. *New England J. Med.*, 1940, *222*, 481–493.
13. Swanberg, H. What radiation technic gives the best clinical results in uterine cervical cancer? Statistical study of 5 year end-results of 3759 treated patients (1927–1931). *Mississippi Valley Med. J.*, 1939, *61*, 57–65.

VOL. 49, NO. 4

THE PRODUCTION AND CHARACTERISTICS OF 3,000 KILOVOLT ROENTGEN RAYS*

By J. G. TRUMP, D.Sc., *and* R. W. CLOUD, M.A.
Massachusetts Institute of Technology
CAMBRIDGE, MASSACHUSETTS

FOLLOWING the development and installation for medical use of a 1,000 kv. air-insulated electrostatic roentgen-ray generator at the Huntington Memorial Hospital in Boston in 1937[1] and of a 1,250 kv. compressed air-insulated generator at the Massachusetts General Hospital[5] in 1940, the High Voltage Group of the Massachusetts Institute of Technology undertook the extension of the electrostatic method to substantially higher voltages.

The resultant generator has produced roentgen rays at steady, constant voltages up to 4,000 kv., using air at 13 atmospheres pressure as the insulating medium, and has produced radiation at voltages up to 4,700 kv., using a combination of air and Freon (CCl_2F_2) at this pressure. For the past year this generator has been used to study the physical properties of roentgen rays produced at these elevated voltages, and particularly to observe the progressive change in these properties over the entire voltage range. Since the spring of 1942, the generator has been available for radiation therapy at 3,000 kv., the preliminary results of which are to be presented by Dr. Richard Dresser in a companion paper.

HIGH VOLTAGE SOURCE

It may be well to review briefly the operating principles of the Van de Graaff type of electrostatic high voltage source and the general features of the generator and tube used in this work. The voltage source, as shown in Figure 1, consists essentially of a well rounded, high voltage terminal about 2 ft. in diameter supported from the ground by a column structure of alternate insulating and metallic spacers. A single insulating belt 12 in. wide travels at high speed within the column and transfers electric charge continuously between ground and terminal. The terminal voltage

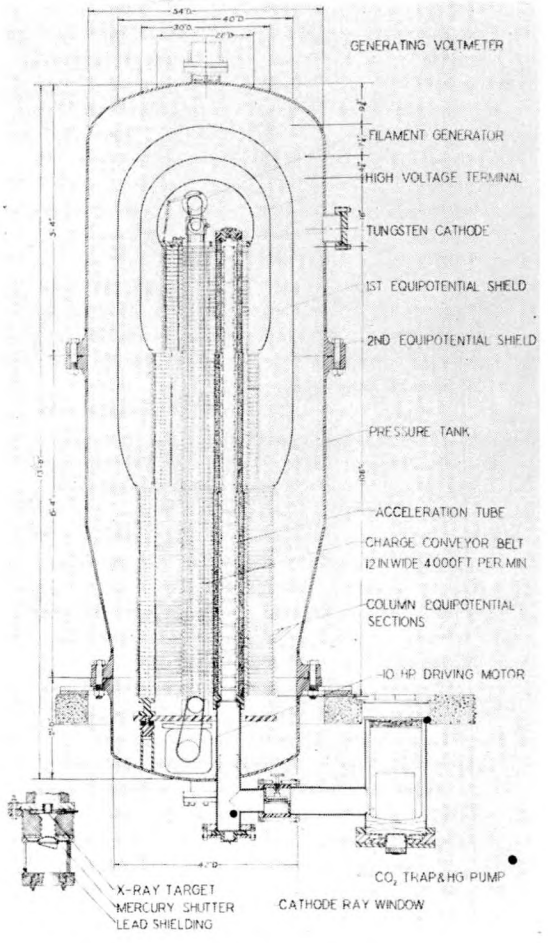


FIG. 1. Roentgen-ray and cathode-ray generator.

of the generator is evenly divided lengthwise of the column by means of resistors so as to produce a uniform gradation in potential from the terminal to the ground plane. This assembly is mounted within a metal

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

pressure tank so that by compression of the gas the electrically charged belt, terminal, and column may be insulated with a medium superior to air at ordinary pressures. The inside dimensions of this tank are $4\frac{1}{2}$ ft. diameter by 13 ft. high.

In operation, negative electric charge is sprayed on the insulating belt at its lower end and hauled up into the high voltage terminal, which acquires a negative potential relative to ground in direct proportion to the stored electric charge. The generator will operate at that equilibrium voltage at which the current transferred to the terminal by the belt is just equal to the current through the roentgen tube and the leakage and control currents characteristic of operation at that voltage. This equilibrium voltage value may be adjusted from a few hundred thousand volts to the maximum voltage by controlling the current sprayed on the charge-conveyor belt.

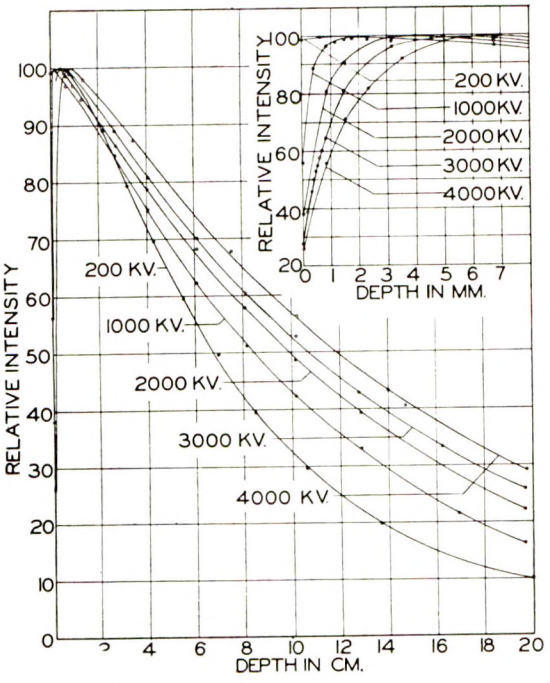


FIG. 2. Depth dose in masonite phantom with 10 by 10 cm. field at 70 cm. distance.

Kilovoltage	Filtration	
200		0.5 mm. Cu
1000	2 mm. Pb	5 mm. Cu
2000	6 mm. Pb	5 mm. Cu
3000	10 mm. Pb	5 mm. Cu
4000	20 mm. Pb	5 mm. Cu

ROENTGEN TUBE

The continuously pumped roentgen tube is located axially within the generator column, the insulating portion extending from a point within the high voltage terminal to the ground end of the column. Beyond this, a metal extension of the tube passes out through the tank bottom and terminates in a water-cooled gold target surrounded by a suitable thickness of lead shielding and provided with beam-defining portals and shutter. The roentgen tube is built up of 100 glass rings between each of which is placed a metallic accelerating and focusing electrode connected to the generator column at that level. The electrons originating at the tungsten filament at the high voltage terminal end of the tube are thus progressively accelerated and focused as they pass axially downward until they arrive at the target with full terminal energy in a well defined focal spot about 1 cm. in diameter.

"SUBCUTANEOUS EFFECT"

The distribution in material of unit density of the ionization produced by roentgen rays over the voltage range of 1,000 to 4,000 kv. has been investigated with this apparatus. Perhaps the most outstanding characteristic at these voltages is the progressive movement of the region of maximum ionization to a depth farther below the surface as the voltage is increased. This phenomenon, which is hereinafter termed "subcutaneous effect," is hardly apparent at 200 kv. As shown in the insert of Figure 2, the ionization intensity for 200 kv. radiation remains practically constant for the first 5 mm. below the surface.

For 1,000 kv. radiation, the "subcutaneous effect" is already considerable and is sufficient to account, in part at least, for the decreased skin erythema which has been demonstrated in this voltage region.[2] The surface ionization intensity at 1,000

kv. begins at about 60 per cent of the maximum value and rises with decreasing rapidity to the maximum found nearly 2 mm. below the surface. Beyond this depth, the intensity falls off slowly in accordance with the laws of absorption and the inverse square law.

For increasing voltages, the depth below the surface at which the ionization intensity has increased to 95 per cent of its maximum value is 0 for 200 kv. radiation, 0.8 mm. for 1,000 kv., 2 mm. for 2,000 kv., 3 mm. for 3,000 kv., and 4 mm. for 4,000 kv. At the same time, the surface intensity diminishes from 98 per cent of the maximum value for 200 kv. radiation, to 56 per cent for 1,000 kv., 38 per cent for 2,000 kv., 28 per cent for 3,000 kv., and 26 per cent for 4,000 kv.

This "subcutaneous effect," observed only for radiation of considerable energy, is due primarily to the increase in the number of secondary electrons in the beam as it penetrates and traverses the phantom material. The depth at which the number of electrons in the beam stops increasing, i.e., the depth of maximum ionization, depends on the average range of the electrons in the phantom material. Since an increased tube voltage increases the range of secondary electrons, it will also increase to a corresponding extent the depth at which maximum ionization occurs. The range of secondary electrons, negligible at 200 kv., becomes sufficient at 1,000 kv. to move the depth of maximum ionization several millimeters below the surface. This tendency increases with voltage. The influence of secondary roentgen rays, on the other hand, is predominant at 200 kv. and diminishes with increasing voltage. Beyond 2,000 kv. the effect of secondary roentgen rays on the distribution of ionization in the material is relatively negligible.

DEPTH DOSE

Figure 2 shows the depth dose over a range of voltages at a distance of 70 cm. with a 10 by 10 cm. field. It is to be noted that the filtration is increased from the standard value of 0.5 mm. copper for 200 kv. to the value of 20 mm. lead and 5 mm. copper at 4,000 kv. Observing the relative intensity at a depth of 10 cm., a steady increase with voltage from 32 per cent at 200 kv. to 57 per cent at 4,000 kv. is noted. The influence on "subcutaneous effect" and

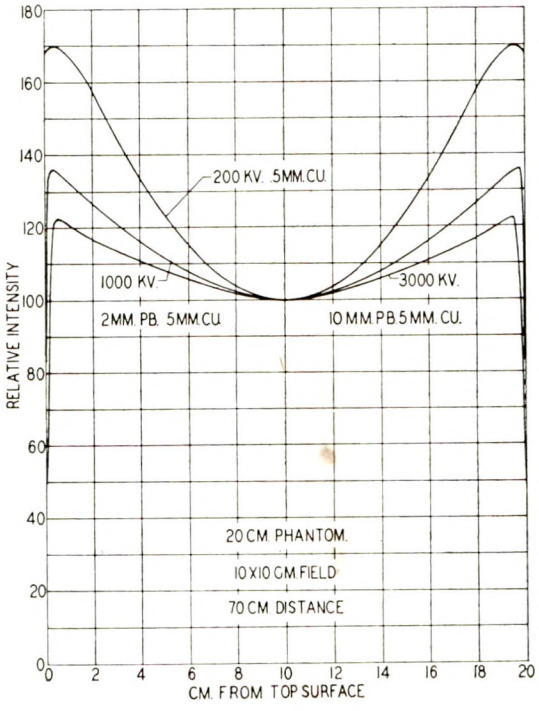


Fig. 3

on depth dose has been studied as a function of treatment distance, filtration, and field size. These measurements show little change in "subcutaneous effect" with increase of 70 to 100 cm. distance, but the depth dose is increased almost as would be expected from the inverse square law. Addition of filtration increases the 10 cm. depth dose and accentuates the "subcutaneous effect," the first increments of filtration being relatively more effective. At 3,000 kv., the 10 cm. depth dose with the 10 by 10 cm. field is 52 per cent at 70 cm. and 57 per cent at 100 cm. The half-value layer in lead for 3,000 kv. roentgen rays filtered with 10 mm. lead and 5 mm. copper is 9.8 mm. Scattering remains small in the 1,000 to 4,000 kv. range, the scattering at

higher voltages being due almost entirely to secondary electrons.[4]

Figure 3 shows the distribution of ionization in a 20 cm. phantom irradiated from two opposite portals with 200, 1,000, and 3,000 kv. roentgen rays. The intensity measurements have been adjusted to 100 per cent at the center of the phantom (10 cm. depth) so that the curves show the relative intensities both at the skin and at the region of maximum ionization for the same intensity at the depth. It is seen that at 200 kv. approximately 170 per cent of the 10 cm. dosage will be delivered to the skin and first 5 mm. At 1,000 kv. the intensity at the skin is about 90 per cent of the 10 cm. value and increases to 135 per cent at 2 mm. For 3,000 kv. the intensity at the skin begins at 50 per cent of the 10 cm. value and increases to 123 per cent at a point 5 mm. below the surface of the skin. This illustration shows, for the simple case of two opposite portals, that the higher voltage roentgen rays will produce a substantially lower dose at the skin and in the intervening region for a given intensity at the depth.

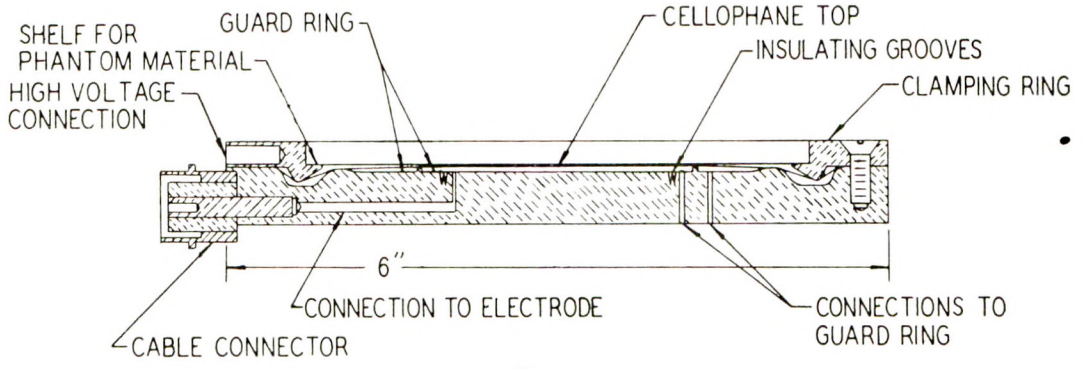


Fig. 4

Method of Measurement

It is evident that precise determinations of the distribution of ionization in depth must be performed with an ionization chamber of negligible thickness.[3] Figure 4 shows the ionization chamber with which this distribution was determined. The bottom of the chamber is made of lucite, an insulating plastic of density 1.2, which is considered as part of the phantom. The upper electrode consists of a sheet of stretched 0.02 mm. cellophane with a conducting coating. By this means, a thin air chamber with an active space $2\frac{1}{16}$ in. in diameter and 1 mm. thick surrounded by a guard ring is obtained. The ionization chamber is submerged in a 30 cm. cube phantom composed of masonite hardboard, and the effect of moving the chamber below the surface is obtained by placing thin layers of corresponding material over the upper surface. A second control chamber is placed 20 cm. from the target to compensate for changes in tube current during readings.

A study was made of the relative merits of a thin-disk ionization chamber and a standard Victoreen thimble chamber in the measurement of extremely penetrating roentgen rays. This indicated that, while the Victoreen thimble chamber is not useful for determining the distribution of ionization close to the surface, it can under proper conditions be used for the determination of the maximum ionization or of the intensity at any substantial depth. When a Victoreen thimble chamber is laid on the surface of the phantom, it will read an intermediate value unless covered with a sufficient thickness of air-wall material to bring the secondary ionization to an equilibrium condition. For 3,000 kv., 3 mm. of lucite or

similar material is an adequate thickness. In supervoltage roentgen therapy, it is desirable that the subcutaneous dose of maximum intensity be taken as the measure of the incident dose.*

The authors take pleasure in acknowledging the generous grant of the Godfrey M. Hyams Trust which has made possible this and previous work at the Massachusetts Institute of Technology on supervoltage techniques. The able assistance of Floyd McIntosh and John C. Stacey is also gratefully acknowledged.

REFERENCES

1. Dresser, R., Trump, J., and Van de Graaff, R. J. Production of supervoltage roentgen rays by means of an electrostatic generator. Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 758–761.
2. Dresser, R., Rude, J.C., and Cosman, B. J. Differences between 200 kilovolt and supervoltage roentgen therapy. *Radiology*, 1940, *34*, 12–16.
3. Quimby, E. H. Measurement of tissue dosage in radiation therapy. *Radiology*, 1939, *32*, 583–590.
4. Trump, J. G., and Cloud, R. W. Physical characteristics of supervoltage roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1940, *44*, 615–618.
5. Trump, J. G., Van de Graaff, R. J., and Cloud, R. W. Compact, supervoltage, roentgen-ray generator using a pressure-insulated electrostatic high voltage source. Am. J. Roentgenol. & Rad. Therapy, 1940, *44*, 610–614.

* For discussion see page 537.

PRELIMINARY CLINICAL OBSERVATIONS ON THE USE OF 3 MILLION VOLT ROENTGEN RAYS*

By RICHARD DRESSER, M.D.
BOSTON, MASSACHUSETTS

IN 1936 a new method for the production of supervoltage roentgen rays was presented at the annual meeting of the American Roentgen Ray Society.[1] An electrostatic generator capable of producing somewhat over a million volts was described. This machine was used for cancer treatment and research at the Collis P. Huntington Memorial Hospital, Boston. The original apparatus was dependent on air insulation, and a considerable space was required for its housing. A second more compact million volt unit operating on the electrostatic principle but insulated by air under pressure has been installed at the Massachusetts General Hospital.[5] A third pressure insulated unit which has been operated at 3 million volts for therapeutic purposes is now in use at the Massachusetts Institute of Technology.

Roentgen rays produced at 3 megavolts have essentially the same physical properties as the gamma rays of radium. However, the high roentgen intensity permits long treatment distances with the result that the depth dose is much greater than it has been possible to obtain with teleradium therapy. It is nearly double the 200 kv., 10 cm. depth dose. In view of this high intensity and increase in depth dose, it has been deemed advisable to proceed with caution in the therapeutic application of these rays. Only cases of pelvic cancer have thus far been irradiated since the factors of absorption, scattering, etc., in this part of the anatomy are analogous to those measured in a phantom. The patients have been treated in groups, with allowance of a sufficient time interval between groups for the observation of any untoward symptoms. All patients received successive daily exposures of 400 r each, delivered to the anterior pelvis through either 15 by 15 cm. or 10 by 10 cm. portals of entry. The larger portal was employed in most instances.

Ionization measurements show that the intensity measured directly on the surface is somewhat less than the intensity measured 4.5 to 5 mm. below the surface. Roentgen dosage is therefore calculated not from the surface measurement, but from the subcutaneous point of greatest ionization. The portal of entry is delineated by means of a light beam, and the coning mechanism is placed well above the patient. The clothes are always removed from the surface irradiated. The treatment factors employed are as follows: 3 million volts constant potential, 100 cm. distance, 10 mm. lead plus 5 mm. copper filter. At 0.5 milliampere the subcutaneous roentgen intensity averages 90 r per minute with the portals employed.

The first group of patients received a total of 1,200 r, that is, three daily treatments of 400 r each. During the follow up period of a month there was no visible skin reaction, and no symptoms of irritation of the bladder or intestine developed. The second group received five daily exposures totaling 2,000 r. During the observation period there was no superficial reaction and no intestinal disturbance. The third group was given 2,400 r which caused diarrhea in all cases but there was no erythema or epilation. The fourth group received 2,800 r which is the largest dose thus far administered. These patients experienced rather severe diarrhea together with some bladder irritation. In no instance, however, was there any redness of the skin or falling out of the pubic hair. All patients tolerated the treatment remarkably well with one exception. This was a case of extensive carcinoma of the bladder, and it was subsequently observed that the response to 200 kv. radia-

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

tion was no better than to supervoltage therapy.

These preliminary clinical findings substantiate the observation that as the wave length of a roentgen-ray beam is decreased the skin tolerance and depth dose are increased.[2,3,4] Because of reaction in the deeper structures a total of 2,800 r to a single pelvic portal has not been exceeded. This is apparently a suberythema dose. It is anticipated that larger amounts of radiation will be tolerated in other parts of the body where the underlying structures are less vulnerable than the intestine and bladder.

No attempt has yet been made to evaluate the effect of 3 million volt roentgen rays on new-growths. The number of patients irradiated thus far has been small, and the maximum follow up period at the time of writing is only five months. The largest tumor dose has been somewhat less than we are accustomed to deliver with 200 kv. roentgen rays. However, the supervoltage dose has been administered in a period of a week, whereas our usual 200 kv. pelvic series extends over a period of about three weeks. The immediate reaction in the deep tissues resulting from supervoltage radiation has been fully as severe as that observed following treatment at lower potentials. The acute symptoms of intestinal and bladder irritation are of approximately the same duration. Thus far there have been no untoward late sequelae.

REFERENCES

1. DRESSER, R., TRUMP, J., and VAN DE GRAAFF, R. J. Production of supervoltage roentgen rays by means of an electrostatic generator. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 758–761.
2. DRESSER, R., and SPENCER, J. Physical and clinical observations on the use of million-volt x-rays. *New England J. Med.*, 1938, *218*, 415–417.
3. DRESSER, R., RUDE, J. C., and COSMAN, B. J. Differences between 200 kilovolt and supervoltage roentgen therapy. *Radiology*, 1940, *34*, 13–16.
4. QUIMBY, E. H., and FOCHT, E. F. Preliminary studies on dosage measurements with million volt roentgen rays. I. The measurement of quantity and quality of roentgen rays in the supervoltage range. II. A comparison of tissue doses from 200 kv. and 1,000 kv. roentgen rays. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 376–399.
5. TRUMP, J. G., VAN DE GRAAFF, R. J., and CLOUD, R. W. Compact, supervoltage, roentgen-ray generator using a pressure-insulated electrostatic high voltage source. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *44*, 610–614.

DISCUSSION ON PAPERS BY DRS. TRUMP AND CLOUD, AND DRESSER

DR. K. E. CORRIGAN, Detroit, Mich. I find myself overawed by the accomplishment of Professors Trump and Cloud in building such a relatively small and compact machine to develop so much power, and to operate in such an apparently reliable and routine manner. It would be difficult to say too much in praise of their engineering ability and technical skill.

The measurements they have presented on the output of this tube are also a real contribution, particularly the measurement of the depth of maximum effect.

It would have been interesting to hear something about the output intensity of this tube. Of course this brings up the old discussion on the use of thimble chambers at this voltage, but perhaps Dr. Dresser will give us some idea of the r per minute per microampere.

Another point I would like to have Dr. Dresser discuss arises from the measurements on both sides of the 20 by 20 cm. phantom. In actual application the beam passes through the patient's body and is at equilibrium with its secondaries on the exit side. In addition the exit portal gets whatever secondary may arise from the material on which the patient is lying. Consequently the exit dose is really a depth dose, and is quite a different thing from a dose of primary radiation applied to the surface from outside.

The authors have made the best possible use of their time, and told us as many of the important points as possible. We can only wait patiently for them to have an opportunity to give us some absorption curves and other important data.

Professor Trump and his associates are to be congratulated for an outstanding advance in physics and technology and for a very fine paper.

Dr. T. Leucutia, Detroit, Mich. These reports dealing with the physical and clinical aspects of a new apparatus for the treatment of cancer represent further most valuable contributions to our radiologic practice. Ever since the advent of supervoltage roentgen therapy, Drs. Trump and Dresser have pursued with great zeal the production of such rays by the old-fashioned electrostatic generator which they have streamlined. After repeatedly traversing unexplored ranges, they now have reached the formidable domain of 4.7 megavolts. The physical achievements are impressive. A yield of 90 r per minute, for example, with a 10 mm. lead and a 5 mm. copper filter at 100 cm. distance with only 0.5 ma. current at 3 megavolts, or a depth dose of nearly double that obtained with 200 kv., are accomplishments that cannot remain without influence in our present-day roentgen therapeutic conception.

The clinical observations, as Dr. Dresser stated, are as yet in the preliminary stage, but even so, it is gratifying to see factual confirmation up to 3 megavolts of the so often disputed theoretical conjecture that with increasing voltages there is an increased tolerance of the skin. On the other hand, a total of 2,800 r, in daily fractions of 400 r, administered over a single pelvic portal, without even producing an erythema, but leading to marked diarrhea with some bladder irritation, is a new type of dose which merits our earnest consideration. Such a dose may do away with the present complicated methods of cross-firing of the deep roentgen therapy, a fact which is responsible for the ever accumulating series of permanent injuries to the normal structures. It is therefore to be hoped that the authors will continue their investigations in the future with equal zeal and that soon they will be able to make additional reports on this most interesting subject.

Dr. Donald W. Kerst, Urbana, Ill. Are there many secondary electrons produced by the cone of the roentgen-ray equipment? In order to obtain the rise in ionization under the skin is it necessary to remove these secondary electrons which would bombard the skin?

Dr. Dresser (closing). First, I should like to thank Dr. Leucutia for his encouraging discussion of the joint paper, and then I shall try to answer the questions that Dr. Corrigan has put.

The first one I think has already been answered in regard to the output of the tube. At 0.5 ma. at a distance of 100 cm., with 10 mm. of lead and 5 mm. of copper ground filter, the output runs 80 to 90 roentgens per minute.

Now as to the exit dose, unfortunately I cannot give any accurate data. This has not been studied in any particular detail. From the charts that Professor Trump and his co-workers have compiled, the exit dose from a field 10 by 10 cm. should be approximately 25 per cent of the maximum subcutaneous dose, but further than that I cannot go.

Then there was a question as to the use of the Victoreen chamber. Apparently the chamber gives relatively accurate air and surface measurements if it is surrounded with a small lucite thimble. Professor Trump and his collaborators have made such a thimble, which is about 3 mm. thick for 3 megavolt rays, and simply slips on over the standard chamber. Then the measurement of air and surface intensities becomes analogous to that made on low voltage radiation with the standard thin wall chamber. In measuring doses below the surface of a phantom it is not necessary to alter the Victoreen chamber in any way. The measurements are perfectly accurate.

In regard to the removal of secondary electrons, let me stress the point that the coning of the beam is done well above the patient, 50 cm., and also care is taken to remove the clothes so that the maximum intensity is delivered as far below the surface as possible. If material of low density is placed on the patient's skin and built up to a thickness of say 5 mm. then the point of maximum ionization occurs directly on the skin.

VOL. 49, NO. 4

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR
Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, cancelled.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary,* E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, cancelled.

EDITORIALS

MEGAVOLTAGE ROENTGEN THERAPY

IT IS customary to designate as supervoltage roentgen therapy that form of irradiation which is carried out with roentgen rays produced by voltages above 250 kv. When the term was originally introduced, the aim was to create a segregation from deep roentgen therapy, and for obvious reasons no attempt was made to limit the upper range to which such therapy may be extended. Recently, important contributions by Trump and Cloud,[1] by Dresser[2] and by Koch, Kerst and Morrison[3] with roentgen rays up to 20 million volts have brought to light certain new features of the physical dose and biological effect which suggest that perhaps the time has now arrived to try to establish where the upper line of demarcation may be drawn and whether or not further segregation may appear advisable from the practical standpoint.

The studies of Trump and Cloud[1] and of Dresser[2] were carried out with roentgen rays produced by voltages from 1 million to 4 million volts constant potential. The most outstanding observation made by these authors was the fact that the ionization in the layers underneath the skin was larger than on the surface of the skin and that the region of maximum ionization moved progressively below the surface as the voltage was increased. This effect, which the authors called the "subcutaneous effect" led to the unusual clinical experience that in patients afflicted with cancer of the cervix such large depth doses could be administered through one single anterior pelvic field that rather severe diarrhea and some bladder irritation resulted without there being any redness of the skin or even epilation of the pubic hair. Obviously a new type of dosage was encountered.

The investigations of Koch, Kerst and Morrison[3] were extended to the range of 20 million volts. To Kerst[4] falls the merit of having made possible the generation of roentgen rays at such extremely high voltages. He, with the ingenuity of a true scientist, solved the not altogether new idea of circular acceleration of the electron and after assiduous work he succeeded in building a new type of roentgen apparatus which he called the betatron. This apparatus somewhat resembles a small cyclotron but its operation is entirely different. The electrons, injected from an electron gun into a circular path within a doughnut-shaped high vacuum roentgen tube, are accelerated by an induction scheme which permits the continuous and direct application of the electromotive force to their stream. In consequence, it is possible to reach, with very small equipment, energies in electron volts corresponding to the voltages generated in the secondary windings of huge transformers. The 20 million betatron has 1 inch of pole diameter

[1] Trump, J. G., and Cloud, R. W. The production and characteristics of 3,000 kilovolt roentgen rays. Am. J. Roentgenol. & Rad. Therapy, April, 1943, *49*, 531–535.

[2] Dresser, R. Preliminary clinical observations on the use of 3 million volt roentgen rays. Am. J. Roentgenol. & Rad. Therapy, April, 1943, *49*, 536–538.

[3] Koch, H. W., Kerst, D. W., and Morrison, P. Experimental depth dose for 5, 10, 15 and 20-million-volt x-rays. *Radiology*, February, 1943, *40*, 120–127.

[4] Kerst, D. W. Acceleration of electrons by magnetic induction. *Phys. Rev.*, 1940, *58*, 841.

Kerst, D. W. Acceleration of electrons by magnetic induction. *Phys. Rev.*, 1941, *60*, 47–53.

Kerst, D. W., and Serber, R. Electronic orbits in the induction accelerator. *Phys. Rev.*, 1941, *60*, 53–58.

Kerst, D. W. A twenty million electron-volt betatron or induction accelerator. *Rev. Scient. Instruments*, 1942, *13*, 387–394.

Kerst, D. W. The betatron. *Radiology*, February, 1943, *40*, 115–119.

per 1 million volts but there is now under construction a 100 million volt betatron which will necessitate only ¾ inch of pole diameter per 1 million volts, thus further reducing material and space.

The experimental results obtained by Koch, Kerst and Morrison[3] entirely confirmed the observations made by Trump and Cloud, and Dresser, and they have demonstrated that at ranges up to 20 million volts the ionization below the surface may amount to several times the incident dose and that the region of the maximum ionization may lie several centimeters below the surface. If, for example, at a target distance of 45 cm. the surface dose was taken as 100 per cent, the maximum ionization amounted to 125 per cent for 5,000 kv., 185 per cent for 10,000 kv., 245 per cent for 15,000 kv. and 310 per cent for 20,000 kv., and the regions of maximum ionization were approximately 1, 2, 2.5 and 3 cm. below the surface for the respective voltage ranges. The depth dose at the conventional 10 cm. below the surface amounted to over 70 per cent for 5,000 kv., 120 per cent for 10,000 kv., 170 per cent for 15,000 kv. and nearly 230 per cent for 20,000 kv. Although these authors did not extend their observations to clinical patients, results along the lines noted by Dresser[2] undoubtedly would be obtained.

The explanation of these new phenomena at very high voltages is most interesting. Failla, Twombly and Marinelli[5] first described what they called the electron equilibrium level of a roentgen beam. They have shown that when a roentgen- (or gamma) ray beam strikes the skin of a patient—or the surface of any phantom used for depth dose measurements—it contains a mixture of secondary electrons from filters, cones, etc., as well as from stray collisions with objects near the beam. Furthermore, there is an addition of electrons from the very superficial layers of the absorbing medium (skin or material of the phantom). As a result, an increasingly larger proportion of ionization is found immediately underneath the surface until at a certain level an equilibrium of the electrons consistent with the quality of the beam and the physical characteristics of the medium is reached. Exhaustive measurements demonstrated that this electron equilibrium level lies within fractions of a millimeter from the surface at 200 kv. (peak) radiation and at a depth of about 1.5 mm. at 1,000 kv. (pulsating) radiation. The biological importance of such an effect on the variation of the surface dose, especially as far as the skin erythema is concerned, was stressed in a former editorial in this JOURNAL.[6]

The extension of the electron equilibrium theory to the radiations produced by the very elevated voltage ranges investigated by Trump and Cloud, and Dresser, and by Koch, Kerst and Morrison encounters no difficulty. The main difference is that here the ionization is entirely due to Compton electrons the range of which plays a paramount rôle. At the voltages studied by Failla, Twombly and Marinelli[5] the ionization from the Compton electrons appeared very near the point where the Compton process occurred, exercising no particular effect on the shape of the depth dose curves. Above 1,000 kv., however, the range of the Compton electrons increases progressively and so rapidly that it leads to increase of the depth dose, on the one hand, and movement of the region of the maximum ionization, on the other. According to Koch, Kerst and Morrison[3] the electrons produced in the Compton process of a roentgen-ray beam from a 20 million betatron may have a range as great as 10 cm. in tissue. Since one may assume that constant ionization is produced along the entire tract of such an electron until the end of its range, it becomes clear that the increase with depth in the number of such electrons must result in gradual increase of the ionization above

[5] Failla, G., Twombly, G., and Marinelli, L. D. A method for decreasing the ionization in the skin applicable to supervoltage x-ray therapy. *Radiology*, 1930, *28*, 693–703.

[6] Leucutia, T. The necessity of a coordinated biological dose system in radiation therapy. (Editorial.) AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 883–887.

that encountered near the surface, leading to a proportionately larger depth dose. The maximum of the ionization is reached at a certain critical level underneath the surface characteristic of the quality of the roentgen-ray beam applied. The gradual absorption of the electrons is followed by a corresponding fall of the ionization and with it of the depth dose.

Evidently, when clinical radiation therapy is administered under such conditions the situation encountered is entirely different from that to which we are accustomed in the ranges below 1,000 kv. Perhaps some advantage may be derived, therefore, by restricting the field of supervoltage roentgen therapy to the limits of from 250 to 1,000 kv. and by creating an entirely new domain for the voltages above 1,000 kv., which then is called megavoltage roentgen therapy. The particular range could be designated by placing the corresponding number of megavolts in a prefix, as, for example, 5, 10, 15 or 20 megavolt therapy.

Exhaustive clinical studies will be required to properly evaluate the therapeutic significance of this extremely penetrating type of radiation and especially its rôle in the simplification of the present day difficult methods of technical application. A great deal could be gained, however, by first trying to establish some correlation between the experimental physical dose as determined by the above investigators and the biological dose as administered to patients. If possible, such correlation may be incorporated into a uniform system of dosimetry including all voltage ranges employed in clinical practice.

It has been suggested formerly in this JOURNAL[6,7] that the biological unit, "skin unit dose," designated with the abbreviation S.U.D., used in conjunction with the r, would have many advantages in specifying a certain dose. This unit has been defined as a surface dose unit and it has been given a physical value, measurable in r, the magnitude of which changes with various voltages. In the ranges used so far it always represented a higher value than the depth dose at any point, except the infinitesimal layers near the surface which are hardly significant from the point of view of clinical application. It has become convenient to express a certain tumor dose in so many per cent of the skin unit dose and since the damage of the skin forms the greatest barrier to any biological overdosage, a measure of safety could easily be established.

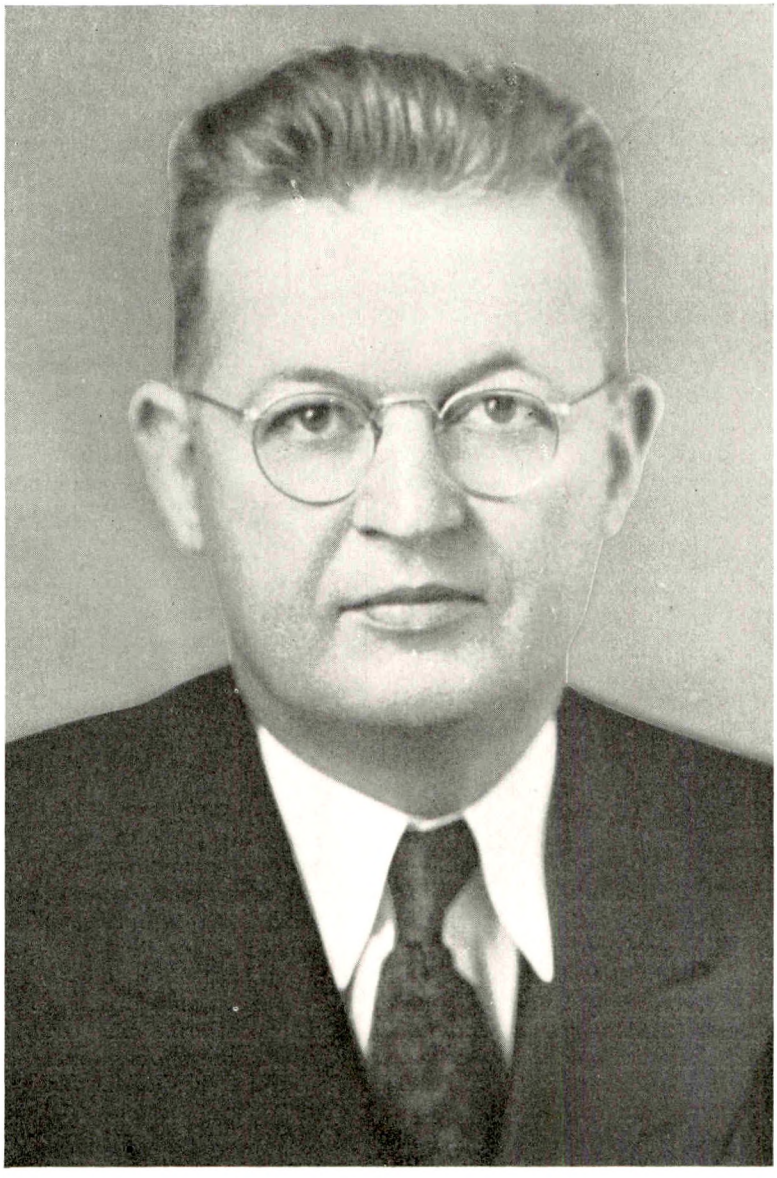
In the megavoltage roentgen therapy, the surface dose represents a smaller value than the depth dose. As has already been stated, the ionization progressively rises to a peak which with increasing voltages lies at gradually deeper layers, becomes broader and acquires a proportionately greater value. Furthermore, the surface dose itself can be critically affected by electrons escaping from the original beam of the acceleration chamber of the betatron or by Compton electrons scattered from neighboring objects. Therefore, if the S.U.D. is introduced as a biological unit, this may be employed in two ways. First, as an extension from the lower voltage ranges in the form of a surface dose unit. In this case, its physical magnitude is determined experimentally along the entire megavoltage scale and the depth dose curves are plotted in percentages of the surface dose. If, for example, a dose of 130 per cent S.U.D. (the maximum compatible with safety) is desired at a certain depth, this will represent a percentage of the S.U.D. as measured on the skin. By using such a procedure, even should stray electrons affect the surface dose, the danger of harm is less than if a too large depth dose were administered at a certain level. Of course the region as well as the broadness of the maximum ionization must also be stated. The second alternative is to calculate the dose not from the surface measurement but from the region of greatest ionization, in which case the S.U.D. would in fact represent a tissue (depth) dose unit. This method, in its

[7] Leucutia, T. Physical and biological dosage in radiation therapy. (Editorial.) AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 367–369.

physical equivalent, i.e., by actually measuring the r, is preferred by Trump and Cloud,[1] and Dresser,[2] as well as by Koch, Kerst and Morrison.[3] The peak ionization is taken as 100 per cent and the doses at the surface as well as at various depths are plotted in fractions of the peak ionization. The region of the peak ionization is stated separately for each location.

It is as yet too early to visualize what form megavoltage roentgen therapy will take in clinical application. The future, however, appears rich in promise and the road leading to it is no longer strewn with insurmountable obstacles.

T. Leucutia



JOSEPH FRANCIS ELWARD
1890–1943

TO MY mind, the saddest words an obituary can contain are "after a long illness." Dr. Joseph F. Elward died on February 6, 1943, in Plains, Pennsylvania, after a very long illness.

Dr. Elward was born in Plains, Pennsylvania, on July 4, 1890. He obtained his early education in Plains and from there he went to the Philadelphia College of Pharmacy from which he was graduated in 1913. Following his graduation he returned to Plains and opened his own drug store. After two years, however, he decided to study medicine and he entered Georgetown Medical School in Washington, D. C., where he attended classes in the daytime and worked

evenings as a registered drug clerk. He was graduated from Georgetown in 1919, president of his senior class, and received an appointment as intern in Providence Hospital in Washington. After serving his internship he opened an office in Washington, engaging in general practice. However, an otitis media dating from childhood made him believe that he had progressive deafness to look forward to, and it seemed wiser to take up a specialty where he would depend less on his hearing and more on his eyesight. He therefore decided to specialize in roentgenology and he served as intern under Dr. P. F. Butler at the Boston City Hospital, Boston, in the Department of Roentgenology from April 1, 1924 to May 1, 1925 and as assistant physician in the Department from May 1, 1925, until August 31, 1925.

Dr. Elward then returned to Washington, D.C., where he became associated with Dr. Charles A. Pfender. Dr. Pfender died in 1926 and Dr. Elward opened his own office for the practice of radiology. In addition to his private practice, in which he was very successful from the beginning, he was Clinical Professor of Roentgenology in Georgetown Medical School and Instructor in Radiology in George Washington Medical School and was radiologist to George Washington and Sibley Hospitals. Notwithstanding this full schedule he found time to devote to research and to the writing of many scientific papers on a variety of subjects.

In 1935 Dr. Elward suffered from a coronary attack and within a year he sustained a second one. With periods of enforced rest he still carried on his practice which always grew larger and he still continued to write many valuable scientific papers. However, late in 1940 he had a cerebral accident which produced at first a slight aphasia and he was never able to work again. He retired to the home of his three sisters in Plains where he remained until the time of his death. To me, his devoted friend for a quarter of a century, it was tragic to witness his gradual transition from a power among men to an invalid progressively feebler in body but indomitable in spirit to the last.

Dr. Elward is survived by his wife, the former Mary Tourville of Plains, two daughters and one son, three sisters, two brothers, and his devoted stepmother.

Dr. Elward was a member of the American Roentgen Ray Society, the Radiological Society of North America, the American College of Radiology and the American Radium Society, as well as numerous local societies.

A letter from Dr. P. F. Butler after Dr. Elward's death pays tribute to him and sums up his outstanding characteristics and qualities. It is quoted in part as follows: "I was very close to Joe and he was one of the men in whom I took a great deal of pride. Because of his outstanding success I was continually holding him up as an example to the younger interns in my department. He was an unusually dependable type of man, even as an intern. He accepted any detail assigned to him—even a disagreeable one—like a good soldier and saw it through to its finish. Perhaps outstanding of his traits was his courteous and respectful attitude toward his seniors, a trait seen all too little nowadays. With such a background it was inevitable that he should make a success of his private practice. He also held to the sound idea that we are physicians first and specialists next. This gave him the opportunity to make use of his wide knowledge of collateral medicine, thus greatly enhancing his value as a specialist. He showed his versatility in his writings and lectures, most of them original contributions. In his death our specialty loses another of its outstanding members."

Ramsay Spillman

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: 1943, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 29–Dec. 3, 1943.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Annual meeting, Brunswick Hotel, Lancaster, Pa., May 15–16, 1943.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

SHREVEPORT RADIOLOGICAL CLUB
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. Herman Klapproth, Sherman, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

FACULTY OF RADIOLOGISTS
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

CONTINENTAL EUROPE

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

WAR CONFERENCE

The medical, surgical and industrial hygiene experts who are so ably safeguarding the well-being of more than 20 million industrial workers have agreed to pool their knowledge and exchange their experiences regarding the many new and complex problems of today's wartime production. For this purpose their organizations—

The American Association of Industrial Physicians and Surgeons,

The American Industrial Hygiene Association, and

The National Conference of Governmental Hygienists—are combining their annual meetings in a four-day "War Conference" at Rochester, New York, May 24–27, 1943. Among the problems to be discussed from a practical standpoint are:

The mass entry of women into industry;

Older-age employees, with their various associated problems; proper placement and employability considerations of the 4-F rejectees;

Rehabilitation and proper employment of those already discharged from the military services because of disabling conditions;

Toxic and other hazards from new substances, new processes, and the use of substitute materials;

Absenteeism; fatigue; nutrition;

Effects of long hours; double shifts; two-job workers; overtime; increased industrial accident rates;

Advances in the treatment of illnesses and injuries, and many others.

This joint meeting will be a report on the state of the nation, by the men who know, in matters of industrial health. Dr. William A. Sawyer, Medical Director of Eastman Kodak, is General Chairman; Dr. James H. Sterner and Lieut. Comm. J. J. Bloomfield are arranging the programs for the industrial hygienists.

Physicians and surgeons, hygienists, engineers, nurses, executives—all who are interested in the problems of industrial health and their solution—are invited to attend as many of the sessions as they can arrange for; no registration fee is required

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

THE DOCTORS MAYO. By H. B. Clapesattle. Cloth. Price, $3.75. Pp. 822, with numerous illustrations. Minneapolis: University of Minnesota Press, 1941.

This large volume is packed with history, recollections and romance. It is a human document. It is a history of the progress and advance of medicine and surgery for the past fifty years. The reader can open the volume anywhere and find fascinating and absorbing pages that identify some element in the development of the most successful and the most original system of integrated medical practice in the whole world. It may be that private enterprise as exemplified in the Mayo Clinic can never be duplicated or extended to this or other countries. Imitations have been ventured and maintained periods of success that were usually measured by the active life span of the leader. The story of the Doctors Mayo shows an undefinable breadth of fundamental sincerity, an undeniable urge to develop along sound, conservative lines, an unlimited ambition to add only able minds, a magnificent courage and confidence in the triumph of righteous effort; in fact, it is impossible to catalogue the many virtues that have contributed to the flowering of institutions and the influences of the Doctors Mayo.

This is probably the greatest success story in the annals of medicine. To the reviewer who made his first pilgrimage to Rochester thirty-five years ago, and met the older Mayo, this record of the Mayo saga becomes a vital document. However, it is inconceivable that any reader could be disappointed in the slowly expanding drama of American surgery as it is personalized by word and photograph from page to page.

There have been innumerable reviews of this interesting book and every one seems to be tinctured with personal recollections of the reviewer. There seems to be no reason why this one should not continue the idea, for every radiologist feels more or less of a proprietary interest in the successful career of radiology at the Mayo Clinic. One remembers the erratic Selby, although this book mentions Dr. J. Grosvenor Cross as the Rochester pioneer roentgenologist who later moved to Minneapolis. The renowned Carman came in 1912 after a brief interlude of the enthusiastic Vernon J. Willey. Carman brought Albert Miller with him from St. Louis as a sort of Boswell or alter ego. This team was given unlimited scope and they proceeded to gather statistics and establish diagnostic values, especially in gastrointestinal roentgenology. Aside from their contributions to roentgen diagnosis the several radiologists at Rochester have been extremely popular with their colleagues throughout the world. The personalities of Carman, Moore, Sutherland, Miller, Camp and Kirklin would probably have carried them far even without the glamour of the Rochester setting. They did take advantage of their unusual opportunities and have shared the harvest of roentgen lore generously.

Therapeutic radiology has been obliged to fight for every inch of acceptance at Rochester. The atmosphere has been surgical in spite of the breadth of vision and the practical approach to a complete medical and surgical service, adorned by research and plumed with graduate instruction. The department of Radium Therapy has been carried on, among others, by Leda J. Stacy, the modest and industrious Bowing and the statistical Fricke. These three have been concerned with pelvic conditions while New and Figi were more interested in radium therapy of the head and neck. Roentgen therapy seems to pursue a conservative course through the scholarly, inquisitive Desjardins, ably seconded by Leddy, Popp and Fear.

Dr. Will Mayo was always most cordial to radiologists and radiological organizations when they visited Rochester. Dr. Charles Mayo indulged in conducting roentgen examinations when Dr. Cross went to Minneapolis, and bore some scars of exposure upon his fingers. As testimony of the appreciation that Dr. Will Mayo had for roentgenology one recalls his welcoming remarks when the American Roentgen Ray Society spent a day at Rochester. To emphasize the tremendous values of visual adjuncts to medicine, he told of his visit to "the Victoria

Hospital in New Castle-on-Tyne where the surgeon, Rutherford Morrison, had printed upon the wall of his operating amphitheater facing the students the following five words 'Sight' in large letters; 'Touch' in smaller letters; 'Hearing' in still smaller letters; 'Smell' in fine print and, last, 'Taste' in print so small as to be hardly distinguishable across the room, this indicating Rutherford's estimation of the five special senses in relation to surgery." Dr. Will Mayo turned this recollection into a neat tribute to the visualized possibilities of the roentgen examination.

It is easy to recollect discussions among both admiring and critical visitors who wondered about the possible perpetuation of what started out to be only a surgical mecca. This volume gives some credit to Frank Billings for his advice to Dr. Will to expand the Clinic's base and cover the whole water front of medicine, surgery and the specialties. Not only has this been done but all avenues of graduate instruction, university alliance, research and allied sciences have been dovetailed into a panoramic institution that dominates the landscape of southern Minnesota. The integral human units that are now part and parcel of the whole have become important cogs in the organizations of medicine and in the medical literature of the whole world.

There will always be a Washington Monument as long as our American Democracy survives and there will always be a Mayo Clinic at Rochester as long as the ideals and the visions of the Doctors Mayo prevail in the councils of the staff organization. Things that are conceived within the minds of men and built by the hands of men can never be as permanent as the wonders of the earth. But there has never been another isolated spot on the face of the earth that has attracted more patients and more physicians and influenced both so successfully as the prairie village of Rochester with its native sons, The Doctors Mayo.

E. H. Skinner

Roentgen Technique. By Clyde McNeill, M.D., Louisville. Second edition. Cloth. Price, $5.00. Pp. 329, with 276 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

This practical volume deals with roentgen-ray anatomy and positioning for roentgenography.

As in the first edition, we are impressed by the excellent manner in which the various standard positions have been described by photographs and line drawings, as well as an accompanying discussion of the projection on the opposite page. To this new second, somewhat enlarged edition, the author has added material on some of the newer procedures, making the volume more complete and comprehensive. The addition of certain references to the literature in some of the special procedures is to be particularly commended.

We recommend this book as one of the best constructed, handy manuals for ready reference that is available at the present time.

Paul C. Swenson

Nutrition and Chemical Growth in Childhood. Volume I. Evaluation. By Icie G. Macy, Ph.D., Director, Research Laboratory, Children's Fund of Michigan, Consultant for Nutrition to the Pediatric Staff of the Children's Hospital of Michigan; Member of the Food and Nutrition Board of the National Research Council, etc. With a Foreword by Hugo A. Freund, M.D., President Board of Trustees, Children's Fund of Michigan. Cloth. Price, $5.00. Pp. 432, with 66 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

This is the first of two volumes written by Icie G. Macy, Director of the Research Laboratory, Children's Fund of Michigan, which presents a summary of an intensive clinical and biochemical investigation of normal children. Volume I, the subject of this review, has the title "Evaluation"; the second volume with the title "Interpretation" will appear in 1943 and will give the results of a continuation of the previous study. The first volume deals particularly with a discussion of clinical examination and developmental records, with biochemical methods, with dietetic and metabolic balance studies and with the average retentions of eighteen food constituents by normal children during many five day balance periods.

The most important aspect of the publication is a summary of balance studies of eighteen different chemical substances in normal children in conjunction with other observations which may be classified as pediatric, anatomic, psychometric, physiologic, anthropometric, roentgenologic and chemical. It is stressed that when the rapid polarographic and spectrographic methods for the determination of substances in biologic material are employed, the results can be made available within a few days after the

termination of the series of observations. These newer methods, according to the author, should be of great practical value in clinical medicine and pediatrics.

No attempt can be made by the reviewer to evaluate the results which appear to be derived from a most careful, thorough and painstaking extended study of normal children, in which all modern methods of study are applied. Conclusions concerning the following are presented: the feeding of recommended allowances, the variability of food stuffs, the basal metabolism, and energy utilization, chemistry of the formed elements of the blood, evaluation of skeletal maturation, roentgenographic gastrointestinal studies, and the accurate sampling of food, urine and feces.

In addition to a study of the total energy exchange, the results of a metabolic balance studies on the following substances are given: nitrogen, calcium, magnesium, sodium, potassium, sulfur, chlorine, phosphorus, copper, zinc, iron, nickel, carbon, fat and complex carbohydrates.

The material presented represents a huge undertaking which has had the extensive cooperation of a large number of individuals. The Trustees of the Children's Fund of Michigan, Dr. Macy, and her associates should be congratulated on the completion of such an important and comprehensive project. The book is an excellent summary of the most important phases of nutrition and growth in childhood and should serve as an excellent and reliable reference text. It should also be of great value to those engaged in nutritional investigations relating to childhood and to all physicians engaged in the care of children.

CYRUS C. STURGIS

DISEASES OF THE NAILS. By V. Pardo-Castello, M.D., Assistant Professor of Dermatology and Syphilology, University of Havana, Member of the American Dermatological Association, etc. With a Foreword by Howard Fox, M.D., Professor of Dermatology and Syphilology, New York University, University and Bellevue Hospital Medical College. Second edition. Cloth. Price, $3.50. Pp. 193, with 98 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

This book presents the subject of diseases of the nails in a concise and comprehensive manner. In addition to the text there are 98 excellent illustrations that give the reader a pictorial representation of many conditions affecting the nails. For the radiologist and general practitioner who often receive complaints from patients concerning nail affections, this book offers an opportunity for an intelligent approach to diagnosis and therapy. This book should be in every doctor's library, and in many instances it will be referred to daily.

The author has collected the material for the book not only from his large practice, but from many others interested in this important subject. The publisher, as usual, has prepared a book in which the type, the paper, the illustrations and the binding are excellent in all details.

EUGENE P. PENDERGRASS

SURGICAL PHYSIOLOGY. By Joseph Nash, M.D., Assistant Professor of Clinical Surgery, New York University College of Medicine; Associate Visiting Surgeon, Bellevue Hospital, New York City; First Lieutenant, Medical Corps, U. S. Army; Assistant Chief of the Surgical Service, Lovell General Hospital, Fort Devens, Massachusetts. Cloth. Price, $6.00. Pp. 496, with 16 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

This book is essentially a condensed text of practical mammalian physiology. It is less detailed and contains fewer illustrations than the earlier physiology texts that were written with the view of correlating basic physiology with clinical medicine. It has as its basis a series of lectures given by the author since 1930 at the New York University College of Medicine as a part of the Graduate Course in Surgery.

The amount of condensation that this work required evidently necessitated the sacrifice of the principle of logical sequence in the secondary structure of the work; as a consequence the reader finds it difficult to retain what he reads.

Critical reading uncovers many contextual contradictions. This is especially true in the chapters on the circulation, surgical shock and respiration. The contradictions that appear are somewhat proportional to the number of primary sources from which the material was drawn. The chapter on the kidney is very well written and the chapters on acid base balance, salt and water balances and the hormones are good. These chapters may well be worth the price of the book.

The text lacks an organized reference to the

physiology of anesthesia. Without a doubt, anesthesia exerts a very great influence upon the integration of physiological processes and consequently any text of "Surgical Physiology" cannot be complete without a discussion of the effects of anesthesia upon physiological processes.

The basic physiologic principles governing growth and repair are also neglected. The reviewer feels that as a consequence the author has missed a golden opportunity for the construction of an interesting and enlightening introduction that could have contained some philosophical consideration of the problems confronting the physiologist and the surgeon. This might have served to make the book a challenge to thought rather than the challenge to memory that it is.

Whatever the faults of the text may be, it is directed toward filling a need that every surgeon knows to be existent but is one that seemingly only can be filled in a satisfactory manner by a collective effort of experienced surgeons and highly trained and experienced physiologists.

It is unlikely that any one man will ever be capable of acquiring a mastery of the ramified and complex divisions of physiology and of surgery that would enable him to write a critically constructed text of "Surgical Physiology."

Should this book stimulate the collaboration of specialists in the fields of physiology and of surgery in writing a comprehensive text, it will have provided of invaluable service.

FREDERICK A. COLLER

DIRECTORY OF MEDICAL SPECIALISTS CERTIFIED BY AMERICAN BOARDS, 1942. Compiled by the Advisory Board for Medical Specialties. Cloth. Price, $7.00. Pp. 2495. New York: Columbia University Press, 1942.

As most physicians know, this Directory is the only official and complete list of medical specialists. It lists them geographically as well as alphabetically and gives not only their professional biographies but in addition full details of special training leading to certification.

While the first edition had a large circulation, being widely used in business and medical organization offices, as well as by individual physicians, it is now obsolete because of the large number of diplomates certified since 1939 by the former boards and also by the addition of Boards of Anesthesiology, Plastic Surgery and Neurological Surgery.

The size of the volume has been increased 50 per cent although 4,000 added names account for about a 30 per cent increase. The disproportion is accounted for by the additional biographical data, this having been amplified both as to past positions, such as internships, new appointments, and military service. Procurement and selective service officials find it very helpful in identifying applicants for commissions and verifying their qualifications.

In these strenuous times few can afford to be without the aid of such a useful book.

E. WALTER HALL

BOOKS RECEIVED

AN X-RAY ATLAS OF SILICOSIS. By Arthur J. Amor, M.D. (Lond.), M.Sc. (Wales), Honorary Physician, Clydach Memorial Hospital; Medical Officer, Mond Nickel Co., Ltd., Swansea. The legends translated into French by Robert E. Horne, M.A. (Wales), Medical Secretary, Mond Nickel Co., Ltd., Swansea. With a Foreword by Sir Wilson Jameson, M.A., M.D. (Aberdeen), F.R.C.P. of the Middle Temple, Barrister-at-Law; Dean of the London School of Hygiene and Tropical Medicine. Cloth. Price, $8.00. Pp. 206, with 72 illustrations. Baltimore: Williams & Wilkins Company, 1941.

THE 1941 YEAR BOOK OF RADIOLOGY. *Diagnosis*, Edited by Charles A. Waters, M.D., Associate in Roentgenology, Johns Hopkins University; Assistant Visiting Roentgenologist, Johns Hopkins Hospital; Associate Editor, Whitmer B. Firor, M.D., Assistant in Roentgenology, Johns Hopkins University; Assistant in Roentgenology, Johns Hopkins Hospital. *Therapeutics*, Edited by Ira I. Kaplan, B.Sc., M.D., Director, Radiation Therapy Department, Bellevue Hospital, New York City; Associate Radiologist, Lenox Hill Hospital, New York City; Clinical Professor of Surgery, New York University Medical College. Cloth. Price, $5.00. Pp. 440, with 486 illustrations. Chicago: Year Book Publishers, Inc., 1941.

INTESTINAL OBSTRUCTIONS: A PHYSIOLOGICAL AND CLINICAL CONSIDERATION WITH EMPHASIS ON THERAPY; INCLUDING DESCRIPTION OF OPERATIVE PROCEDURES. By Owen

H. Wangensteen, B.A., M.D., Ph.D., Professor of Surgery of the University of Minnesota and Surgeon-in-Chief of the University of Minnesota Hospital. Second Edition. Cloth. Price, $7.00. Pp. 484, with 143 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

Plastic Surgery of the Breast and Abdominal Wall. By Max Thorek, M.D., LL.D., F.I.C.S., F.I.C.A., K.L.H. (France); K.C.I.; C.O. St. Alex; Medal of Hon. Rep. of Venezuela; Professor of Surgery, Cook County Hospital; Consulting Surgeon, Municipal Tuberculosis Sanitarium, Chicago; Surgeon-in-Chief, American Hospital of Chicago, etc. With an Introduction by Rudolf Nissen, M.D., F.I.C.S., Formerly Associate Professor of Surgery of the University of Berlin, and Professor and Head of the Department of Surgery of the Medical University of Istanbul, Turkey. With a Foreword by J. Eastman Sheehan, M.D., F.A.C.S., Professor of Plastic Reparative Surgery, New York Polyclinic; Surgeon, Morrisania City Hospital, New York; Associate Surgeon and Lecturer, International Clinic, Lariboisiére Hospital, Paris, France. Cloth. Price, $16.50. Pp. 446, with 458 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

Nutrition and Chemical Growth in Childhood. Volume I. Evaluation. By Icie G. Macy., Ph.D., Director, Research Laboratory, Children's Fund of Michigan, Consultant for Nutrition to the Pediatric Staff of the Children's Hospital of Michigan; Member of the Food and Nutrition Board of the National Research Council, etc. With a Foreword by Hugo A. Freund, M.D., President Board of Trustees, Children's Fund of Michigan. Cloth. Price, $5.00. Pp. 432, with 66 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

Occupational Tumors and Allied Diseases. By W. C. Hueper, M.D., Assistant Director and Principal Pathologist, Warner Institute for Therapeutic Research, New York City. Cloth. Price, $8.00. Pp. 896. Springfield, Illinois: Charles C Thomas, 1942.

A Manual of Radiotherapy. By Murray M. Friedman, M.D., Assistant Professor of Radiology, College of Physicians and Surgeons, Columbia University; Assistant Radiologist, Presbyterian Hospital, New York, N. Y. Paper. Price, $1.50. Pp. 86, with 30 illustrations. Ann Arbor, Michigan: Edwards Brothers, Inc., 1942.

Protection of Radium During Air Raids. National Bureau of Standards Handbook H38. Issued by the U. S. Deparment of Commerce, National Bureau of Standards. Paper. Price, 10 cents. For sale by the Superintendent of Documents, Washington, D. C. Pp. 17, with 3 illustrations. Washington, D. C.: United States Government Printing Office, 1942.

Directory of Medical Specialists Certified by American Boards, 1942. Compiled by the Advisory Board for Medical Specialities. Cloth. Price, $7.00. Pp. 2495. New York: Columbia University Press, 1942.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

DUPLICATION OF ROENTGENOGRAMS BY THE LIGHT REVERSAL PROCESS*

By GEORGE C. HENNY, M.D., GUSTAVUS C. BIRD, JR., M.D., *and* HERBERT M. STAUFFER, M.D.
PHILADELPHIA, PENNSYLVANIA

IT IS well known among news photographers that a negative can be made from another negative by the light reversal process. In other words, negatives can be directly duplicated. We have been surprised to find how few roentgenologists are aware of this process which can be used also with roentgenographic film so as to duplicate roentgenograms. Duplicates of roentgenograms can be made very conveniently. Special film and developer are not required, and the process, which is described below, is so simple that anyone can do it. The only special piece of equipment required is an ordinary photographer's printing frame large enough to hold the film to be copied.

The roentgenogram which is to be duplicated is placed on the clean glass of the printing frame. On top of this, in the darkroom, is placed an ordinary unexposed roentgenographic film of the same size. The printing frame is then closed, thereby clamping the unexposed film tightly against the roentgenogram. The glass of the printing frame may then be covered with a piece of black paper, carried outside or to an *open* window (without fly screen on it) and there exposed directly to the sunlight for about thirty seconds. The printing frame is taken to the darkroom and the film is given standard development. When completely processed, the film will be a close duplicate of the original. The time of exposure to the sunlight will depend somewhat on the time of the day and the clearness of the atmosphere, and also upon the general density of the film to be duplicated. Since there is a great deal of latitude in this process, the exposure does not have to be carefully made, and thirty seconds is a good starting point. If the resulting film is too dark, the exposure to the light should be increased, and if it is too light, it should be decreased. This is the opposite of ordinary photographic procedure because of the reversal process. If the sun is not shining when the duplications have to be made, it is possible to use artificial light, but the results may not be quite as good. In this case perhaps the simplest procedure is to place the printing frame with the roentgenogram and underlying film directly against the glass of a film illuminator. The exposure time depends on the brightness of the illuminator but in most cases ten or fifteen minutes will be required. The film is developed in the darkroom in the usual manner, and the result should be a close duplicate of the original. If the light intensity over the surface of the illuminator is not uniform, the duplicate will show this unevenness.

A fair duplication can be made by exposing the film 20 inches below a 100 watt light for thirty minutes. This film will probably be darker than the original but will have good diagnostic detail.

To show the progress of the reversal process, a roentgenogram was made of an aluminum stepladder. The exposure was

* From the Department of Radiology, Temple University Hospital, Philadelphia.

so chosen that the range of photographic densities was between 0.5 and 2.2 as shown by the broken line of Figure 1. This film was then duplicated, using Eastman Blue Brand roentgen film, by exposure to the sunlight for 0.2, 1, 3, 10 and 30 seconds. The duplicates thus exposed were measured with a densitometer and the data were obtained for the curves of Figure 1. Here it is seen that the longer the exposure, the less dense is the resulting film after development. Thus at 0.2 second (this exposure could not be accurately timed) the film is very black throughout the whole range, and it is evident that there is very little contrast. As the exposure to the sunlight is increased, it is found that at thirty seconds the density curve is nearly superimposed throughout the whole density range on the curve of the original. This shows that a nearly exact duplicate can be made, as far as density is concerned. The fineness of detail suffers slightly, due undoubtedly to the fact that the films are the double emulsion type. Bone trabeculations can easily be seen on the duplicate film so that if the original film and its duplicate are placed side by side and viewed at the usual distance, very little difference between the two can be observed.

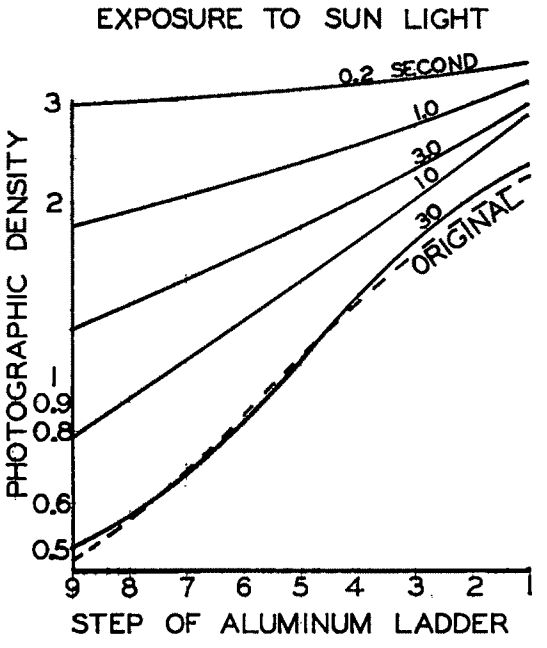


Fig. 1. Photographic density curves of duplicates of a roentgenogram of an aluminum stepladder. The original roentgenogram, having nine density steps, is represented by the broken line curve. The copies of the original were made by printing it on Eastman Blue Brand roentgen film, exposure being made to the morning sun for the times indicated on each curve. The films were developed in the usual manner in Eastman Kodalk X-Ray Developer for six minutes at 65° F.

INDEX TO ABSTRACTS

ROENTGEN AND RADIUM THERAPY

Spangler, D.: Effect of x-ray therapy for closure of the epiphyses 558

Baird, L. W.: Roentgen irradiation of calcareous deposits about the shoulder 558

Klein, I., and Klemes, I. S.: Treatment of peritendinitis calcarea in the shoulder joint 558

Stone, R. S., and Robinson, J. M.: Roentgen irradiation of the pelvis in carcinoma of the cervix uteri 558

Cantril, S. T., Buschke, F., and Parker, H. M.: Irradiation in cancer of the cervix uteri 559

Liljencrantz, E., and Newell, R. R.: Technic of irradiation of cancer of the uterine cervix, combining radium and supervoltage roentgen rays 560

Sandler, B.: Radium distribution factor in carcinoma cervix therapy 560

Doub, H. P., Pratt, J. P., and Jones, H. C.: Combined irradiation and surgery in treatment of carcinoma of the pelvic colon 561

Bowing, H. H., and Fricke, R. E.: Malignant disease of rectum and rectosigmoid treated with radium 561

Priestley, J. T., and Schulte, T. L.: Treatment of Wilms' tumor 561

Munger, A. D.: Experiences in treatment of carcinoma of prostate with irradiation of the testicles 562

Randall, A.: Irradiation control of testicular tumor metastases 562

Mertz, H. O., Howell, R. D., and Hendricks, J. W.: Limitations of irradiation of solid renal tumors in children 562

Kreutzmann, H. A. R.: Treatment of Hunner's ulcer with deep x-ray therapy 563

Hauser, H.: Roentgen therapy in tuberculous cervical lymphadenitis 563

Kelly, J. F., and Dowell, D. A.: Twelve-year review of x-ray therapy of gas gangrene 564

Dowdy, A. H., and Sewell, R. L.: Roentgen radiation in experimental Clostridium welchii infection (gas gangrene) in dogs 564

Hodges, F. M., Snead, L. O., and Berger, R. A.: Roentgen therapy of hemangiomata 564

Arons, I.: Further studies on radiotherapy of lymphoblastoma 565

Popp, W. C., and Watkins, C. H.: Roentgen therapy for chronic macrolymphocytic and mesolymphocytic lymphatic leukemia 565

Jacox, H. W., and Freedman, L. J.: Roentgen treatment of myxomatous cutaneous cysts 566

Cipollaro, A. C.: Irradiation in dermatology 566

Ashbury, H. H.: An ointment for relief of discomfort due to severe irradiation epidermitis 566

Roberts, F.: Limitations of biopsy in x-ray therapy 566

Jacoby, P., and Spotoft, J.: Investigations into significance of sedimentation reaction as regards the prognosis of irradiation of cancer patients 567

MISCELLANEOUS

Lindgren, E.: An apparatus for radiography in immediate connection with radioscopy 567

Clark, K. C., and Poulsson, K. T.: Further experiments in x-ray screen photography 567

Hodes, P. J., and Griffith, J. Q.: Effect of roentgen irradiation upon lymphatic flow in rats 567

Glücksmann, A.: Preliminary observations on the quantitative examination of human biopsy material taken from irradiated carcinomata 568

Sugiura, K.: Effect of high and low body temperatures upon the growth of irradiated mouse sarcoma 180 568

Denstad, T.: Radiosensitiveness of bone marrow 568

Fried, C.: Roentgen treatment of experimental pneumonia in the guinea-pig 569

Chambers, R., and Cameron, G.: Reaction of kidney tubules in tissue culture to roentgen rays 569

Henshaw, P. S.: Induction of multipolar cell division with x-rays and its possible significance 569

Westermark, N.: Study of the cardiac movements simultaneously recorded by roentgen-cinematography and electrocardiography 570

Taylor, L. S.: New x-ray laboratory of the National Bureau of Standards 570

Cassen, B.: Some recent contributions of physics and engineering research to radiology 570

Stanford, B.: Research into the physical factors concerned in indirect radiography. I 570

Stanford, B.: Research into the physical factors concerned in indirect radiography. III 571

Stanford, B.: Research into the physical factors concerned in indirect radiography. IV. 571
Stanford, B.: Research into the physical factors concerned in indirect radiography. V 571
Williams, M. M. D.: Effect of shockproof cables and condensers on two-valve half-wave rectification 571
Jacobs, L. G.: Accuracy of focal spot size determination 572
Glasser, O.: Evolution of dosimeters in roentgen ray therapy 572
Meyer, W. H.: Depth dose calculation wherein absorption in unit volume in the depth, i.e. volume depth dose, is the index of effective radiation 572
Lamerton, L. F.: Physical investigations with 140 kVp radiation 572
Reinhard, M. C., and Goltz, H. L.: Note on the distribution of surface radiation from a million-volt generator 573
Flint, H. T., and Wilson, C. W.: Homogeneity of dosage distribution in radiation teletherapy 573
Clarkson, J. R.: Depth doses in fields of irregular shape 573
Mayneord, W. V., and Lamerton, L. F.: Survey of depth dose data 573
Happey, F.: Integration of radiation dosage and absorption of energy in tissue for X and gamma radiation 573
Ting, T. P.: Simple calculator for roentgenographic mensuration 574
Marinelli, L. D.: Milliammeters at ground potential in x-ray tube circuits 574

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN AND RADIUM THERAPY

Spangler, Davis. The effect of x-ray therapy for closure of the epiphyses: preliminary report. *Radiology*, Sept., 1941, *37*, 310–315.

There are various causes for unequal length of the legs. Orthopedic lengthening of the short leg requires months of hospitalization and surgical shortening of the long one is usually objected to. The author suggests closing of the epiphyses at the knee of the long leg, preventing further growth and allowing the shorter leg to catch up. This is a preliminary report to suggest further trial of the method, as he has only used it in 4 cases, which are described. The treatment was successful in 3 cases and failed in the fourth. He believes that about 3,000 r given in one fractionated series will bring about closure of the epiphyses. He irradiates through four portals, one anterior, one posterior and one on each side, giving 750 r to each with 140 kv., through 0.25 mm. copper. The fractionating is arranged so as to produce tanning but not epidermitis. The knee joint cartilages should be protected with lead strips.

These children were treated just before the spurt of bone growth that takes place at puberty. He thinks the results would be more satisfactory if they were treated at six to ten years of age.—*Audrey G. Morgan.*

Baird, L. W. Roentgen irradiation of calcareous deposits about the shoulder. *Radiology*, Sept., 1941, *37*, 316–324.

The author discusses the roentgen treatment in 18 cases of calcified subacromial bursitis. In diagnosis two exposures should be made, one with external rotation of the humerus and one with internal rotation. As the deposits may be bilateral it is best to make exposures of both shoulders, even though the pain may be bilateral. In very acute cases it is often necessary to use a soft tissue technique as the shadows of the deposits are very faint.

Of this series of cases 9 were acute, 5 subacute and 4 chronic. The technique was as follows: 300 r (measured in air) in a single dose through a 15×15 cm. cone angled slightly toward the body over the anterolateral portion of the shoulder: 200 kv., constant potential, 1.0 mm. copper plus 1.0 mm. aluminum filter, 50 cm. distance, 18 ma. Only one exposure was necessary to relieve pain and restore function in all of the acute and 2 of the subacute cases. In the 3 other subacute cases two treatments were necessary. Two of the chronic patients were relieved by three treatments at intervals of four weeks while the treatment was a failure in the other two. This method is not adapted for the treatment of chronic cases in which the chief symptom is limitation of motion. This is caused by fibrosis and adhesions and is not relieved by irradiation.—*Audrey G. Morgan.*

Klein, I., and Klemes, I. S. Treatment of peritendinitis calcarea in the shoulder joint. *Radiology*, Sept., 1941, *37*, 325–330.

The authors give a tabulation of their cases of peritendinitis calcarea of the shoulder joint from 1932 to 1940. Physiotherapy in the form of infra-red therapy and diathermy was used from 1932 to 1937 while roentgen irradiation was used from 1937 to 1940. The roentgen technique was as follows: 75 to 100 r in air every three to seven days for four doses. If necessary a second course was given after a month's rest. The physical factors were: 125 kv., 4.0 mm. aluminum filter, 5 ma., 30 cm. distance, field 8×8 cm., or 180 kv., 4 ma., 40 cm. distance, 0.5 mm. copper and 1.0 mm. aluminum filter, field 10×10 cm. The choice of method depended on the thickness of the shoulder. Both gave the same results. The calcifications disappeared under roentgen treatment and the period of disability was greatly shortened as compared to that with physiotherapy. The average period of disability with physiotherapy was fifty days, with roentgen treatment ten days. Seven illustrative cases are described and illustrated with roentgenograms.—*Audrey G. Morgan.*

Stone, Robert S., and Robinson, J. Maurice. Roentgen irradiation of the pelvis in carcinoma of the cervix uteri. *Radiology*, May, 1941, *36*, 521–533.

In the authors' plan of treatment radium is used for the primary lesion in the cervix and

roentgen irradiation is used for the treatment of the territories to which the lesion is apt to spread. If the tumor of the cervix is small and well localized a complete course of radium treatment is given. If the tumor is in Stage I or II this is followed by a Wertheim operation; if it is more advanced roentgen treatment is given. But if the growth is large and extensive, roentgen treatment is given first in an attempt to decrease its size, and radium treatment is given two to six weeks later.

Ninety per cent of lymphatic involvement occurs in the primary lymph nodes, which must therefore be irradiated. These are the hypogastric, the obturator, the iliac, the sacral and the parametral nodes. The cancer may extend directly into the parametrium and the vagina and these must be included in the fields to be irradiated.

The fields to be irradiated should be marked out carefully and the beam should be directed not at the cervix but at the lateral walls of the true pelvis and the anterior surface of the sacrum. The object is to irradiate not a certain area of skin but the structures lying beneath it and the physician himself should attend to the placing of the patient and the direction of the beam. This should never be left to technicians for it is a medical and not a technical problem. The amount of irradiation given should be as much as the normal tissues will bear.

The authors have found that six fields, two anterior, two posterior, and two lateral, give the best internal distribution of the irradiation.

They compare the results in two series of cases in the first of which they used 200 kv. therapy, half-value layer 1.05 mm. copper in which one anterior and one posterior field 20×20 cm. and two lateral fields 10×20 cm. were used. The total dosage rarely exceeded 2,000 r, in air, per field. In the second series they used 1,000 kv., with anterior and posterior fields 20×20 cm. but no lateral fields; at first 316 r and later 240 r, in air, was used per field per treatment. There was a higher percentage of survivals in the group treated with 200 kv., but there was evidence in both that the growth of the cancer was slowed or stopped by the roentgen treatment.—*Audrey G. Morgan.*

CANTRIL, SIMEON T., BUSCHKE, FRANZ, and PARKER, H. M. Irradiation in cancer of the cervix uteri. *Radiology*, May, 1941, *36*, 534–542.

In treating cancer of the cervix an attempt should first be made to determine the anatomic limits of the growth and the effect it has had on the patient. As the majority of deaths are due to occlusion of the ureters, cystoscopy and intravenous urography must be used in many cases. Among 19 Stage IV cases in which intravenous urography was done half showed some degree of ureteral obstruction.

The authors do not give purely palliative treatment, for the amount of palliation obtained is rarely in proportion to the severity of the treatment. Patients with ureteral obstruction are treated with the object of restoring permeability of the ureter if possible. They follow no rigid outline of treatment as this is a disease in which individualization is most important. In all except Stage I cases they supplement radium treatment with roentgen irradiation, using 800 kv., 10 ma., 4 mm. lead filtration, 100 cm. distance, with an intensity of 23.5 r per minute for a field of 10×14 cm. Types of radium applicators are shown. As a rule they give a total radium dose of about 8,000 mg-hr., equivalent to about 4,500 r. Radium should be given first, followed by roentgen irradiation unless anatomical conditions make this method impossible. A rectal reaction can hardly be avoided if sufficient treatment is given. They use two anterior suprapubic and two posterior lumbosacral fields, and if greater dosage to the parametrium is desirable also two oblique ischiosciatic fields. The size of the fields is 10×10 cm. in small patients and 10×14 cm. in larger ones.

Isodose curves were determined in a pressdwood model of the pelvis of a living subject. A study of these measurements shows that a roentgen-ray dose of 2,600 r contributes little to the combined dosage at the periphery of the broad ligaments in a broad pelvis. It is known clinically that roentgen therapy rarely cures a cancer of the cervix that has spread into the broad ligaments and to the wall of the pelvis. They show also that the effective range of radium is sufficient for Stage I and that in Stage II the roentgen-ray contribution is not apt to increase the dosage beyond the tolerance level. In Stage III an increase of either the radium or roentgen-ray dose may be necessary to control outlying metastases. In patients with a small pelvis this is best obtained by increasing the radium dosage and in patients with a large pelvis the roentgen-ray doses may be increased with greater safety than in smaller ones, though

wherever radium can be used its effects can more readily be localized in the places where it is most needed and normal tissues are injured less.

Radium is the more important source of radioactivity and the success of its use should not be endangered by using external roentgen treatment first and carrying it to the limit of tolerance of the normal tissues. In Stage IV in which radium cannot be used the curability cannot be increased solely by increasing dosage by supervoltage therapy. There are other factors than dosage to be considered; the biologic effects of radiation on normal and malignant tissues are of the first importance. For certain kinds of cells there is no lethal dose and there is no certainty that tissues will be destroyed by any given irradiation.—*Audrey G. Morgan.*

LILJENCRANTZ, ERIC, and NEWELL, R. R. Technic of irradiation of cancer of the uterine cervix, combining radium and supervoltage roentgen rays. *Radiology*, May, 1941, *36*, 543–549.

For the past few years the authors have been using very hard roentgen irradiation (half-value layer = 2.7 mm. Sn). They use three fields at 120 degrees, one suprapubic and two posterolateral (gluteal). The fields are 15 to 16 cm. circles. A sketch is given showing the entrances and exits. As external irradiation alone cannot give a third of the dosage at the cervix attained by radium, radium treatment is added. They believe that roentgen irradiation should be used first and radium afterward. They treat patients six days a week with rotation of the three fields. The posterior areas are generally given 400 r each time and the suprapubic area 300 r. Backscatter adds 20 per cent. In a month the limits of skin tolerance will have been reached with 3,600 r tissue dose in front and 4,800 r gluteal. Radium is applied once within a few days of the completion of the roentgen treatment. Filtration 2 mm. platinum. Time usually thirty hours, giving a total of 3,000 mg-hr.

They have used this technique three years. They have 5 patients well after that time. Forty are living less than three years after treatment, 30 of them more than one year, but 13 still have visible cancer. All of these patients were in Stages II and III. Of the 14 who have died all but two were in Stage III.—*Audrey G. Morgan.*

SANDLER, BERNARD. The radium distribution factor in carcinoma cervix therapy, with a comparison of techniques. *Brit. J. Radiol.*, Sept., 1941, *14*, 284–293.

Tables are given showing the dose delivered to different parts of the pelvis by various techniques with different methods of distribution of radium. The values assumed as maximum tolerance doses are for the vaginal vault 18,000 to 20,000 r, for the cervix 30,000 r and for the rectovaginal septum 5,000 r. An examination of the different techniques shows that if 6,000 r is accepted as the cancericidal level no technique with radium alone delivers this dosage at 5 cm. from the midline and few can deliver it at more than 3 cm. from the midline.

With all techniques it is found that the size of the vagina has a very great effect on the depth dose, an effect even greater than that of the technique used. A single source of radium will not give the best results. Radium must be applied from at least two vaginal sources. Each size of vagina must have its own technique; the vaginal tolerances must be determined and then two sources of radium used in such a way that the maximum tolerances are fully utilized; the radium must be placed as far away as possible from the vaginal mucosa and as large as possible a weight of radium must be used so that the largest possible depth dose may be given. The results showed that corks are better than box applicators.

Roentgen irradiation causes stenosis of the vagina and therefore if roentgen treatment is given some days before the insertion of radium the available space in the vagina will be reduced by the roentgen irradiation. Radium should therefore be given first or, if not, the radium should be inserted very shortly after the roentgen irradiation so that there will not be time for stenosis to occur.

Each vagina must have its own technique carefully worked out and the relations of uterine and vaginal radium to the depth dose and to each other must be determined accurately. It must be possible to give the calculated dosage exactly without any influence by the operator. Therefore factors such as different degrees of pressure in packing, the stiffness of the springs used in the Paris technique, etc., must be eliminated. A solid applicator made in sections is suggested, which fills the vagina and fornices completely so that no packing is necessary. The

distance between the radium and mucosa and between the different radium sources is exactly fixed. A specially designed applicator is necessary for each vagina in order to give the predetermined maximum tolerance dose. The radium dosage can be correlated with any roentgen technique.—*Audrey G. Morgan.*

Doub, Howard P., Pratt, Jean P., and Jones, Horace C. Combined irradiation and surgery in treatment of carcinoma of the pelvic colon. *Radiology*, Nov., 1941, *37*, 575–580.

Since 1924 the authors have used a combined method of surgery and irradiation in the treatment of cancer of the colon and rectum at the Henry Ford Hospital in Detroit. They first give roentgen irradiation consisting of a daily full erythema dose around the pelvis through four fields. The physical factors are: 200 kv., 25 ma., 50 cm., focus-skin distance, 0.5 mm. copper and 1.0 mm. aluminum filtration, 720 r. After from four to six weeks, operation is performed. The technique has to be varied according to the case but in the majority of cases a one-stage abdominoperineal or combined anterior and posterior resection can be used. Some surgeons condemn preoperative irradiation because they say it increases the risk of operation but the authors have found, on the contrary, that it decreases it. Possibly part of this difference of opinion is due to the time interval between irradiation and operation. If operation is performed too soon during the period of engorgement it may increase the risk. But if it is postponed until the patient's physical condition has reacted favorably it decreases the risk. Irradiation also seems to furnish a certain degree of protection against peritonitis. This finding has been confirmed by animal experiment.

In the authors' series of cases there was 8 per cent postoperative mortality, 46 per cent lived less than five years and 46 per cent more than five years. If the cases are counted in which only surgical excision was performed the percentage of five year survivals is 60 per cent. This is probably because the cases treated by operation alone were early cases, while many of those treated by irradiation were inoperable until after irradiation was given. This method seems to raise the limit of operability in patients who otherwise would be inoperable.—*Audrey G. Morgan.*

Bowing, Harry H., and Fricke, Robert E. Malignant disease of the rectum and rectosigmoid treated with radium. *Radiology*, Nov., 1941, *37*, 569–574.

It has been calculated that 5 per cent of all malignant disease of the body occurs in the sigmoid and rectum. If untreated, rectal cancer is very painful and accompanied by hemorrhage, foul rectal discharge and total disability. About 65 per cent of the cases are inoperable when they come for treatment. The great importance of radiation therapy is therefore apparent for life can be lengthened and made much more comfortable for these patients. They are usually elderly people with other degenerative diseases.

Treatment is generally with radium which may either be implanted in the tumor or if the tumor is accessible given by the contact method, two tubes containing approximately equal amounts of radon filtered through 0.5 mm. silver and 1 mm. brass enclosed in 2 mm. soft rubber being strapped together to form a small plaque which is placed directly against the tumor. Several applications may be necessary, probably one a day, to cover the entire growth adequately. The usual dosage for cases which have not had colostomy is from 40 to 100 mc-hr. per square centimeter of diseased surface. The total dose is heavy. A table is given showing the dosage at various depths with given amounts of surface radiation.

No routine technique can be given because the cases vary so greatly. The results depend to a great extent on the skill, care and patience of the radiologist. Treatment is necessarily difficult and tedious. Early diagnosis and treatment of polyps of the rectum should reduce the incidence of cancer of the rectum. In 1934, 500 cases were reported from the Mayo Clinic. Of this group 193 (39 per cent) survived for three years, five years or ten years or more. Counting only the patients who were given preoperative treatment 45 per cent survived.—*Audrey G. Morgan.*

Priestley, J. T., and Schulte, T. L. The treatment of Wilms' tumor. *J. Urol.*, Jan., 1942, *47*, 7–10.

The proper method of treatment of Wilms' tumor is still a subject of controversy. Most urologists agree on preoperative irradiation, nephrectomy and postoperative irradiation.

The finding of viable tumor cells at operation after preoperative irradiation indicates that irradiation alone is not adequate. At the Mayo Clinic no case of Wilms' tumor treated by irradiation alone survived for five years.

An argument which has been advanced for immediate operation without preliminary irradiation is that metastases may occur during the three to six week interval which treatment requires. This argument was felt to be applicable in one of the authors' cases in which a chest roentgenogram prior to beginning irradiation showed no evidence of metastasis. One month later, a chest roentgenogram after nephrectomy showed extensive pulmonary metastases. Obviously, it could not be proved that these metastases were not present on the original examination although not demonstrable.

Arguments in favor of preoperative irradiation are that surgical removal is facilitated due to decrease in size of the tumor. This means less operative morbidity and mortality.

In the experience of the authors the best results have been obtained from nephrectomy combined with pre- and postoperative irradiation.—*R. M. Harvey.*

Munger, A. D. Experiences in the treatment of carcinoma of the prostate with irradiation of the testicles. *J. Urol.*, Nov., 1941, *46*, 1007–1011.

The occasional beneficial results occurring in cancer of the breast following irradiation of the ovary suggests the possible value of suppression of testicular function in cancer of the prostate. Testicular hormonal activity can be suppressed by delivery of 500 roentgens to the testicle. In a series of 11 cases the author delivered 500 roentgens to each testicle by means of supervoltage therapy in addition to the scattered radiation that was delivered there from other portals used in the routine treatment of the prostate gland.

Of 45 cases treated by resection and irradiation, 10 survived while 8 of 11 cases treated with resection, irradiation and additional testicular irradiation survived. The survival time of 5 of the 8 patients ranged from three to seven years. The prostatic bed appears much more resilient in these cases as compared with similar cases treated without the additional testicular irradiation. In 2 cases with pelvic metastases, the metastatic sites appear to have become stabilized although still present.

The author feels that additional irradiatio to the testicle adds something definite to th treatment of cancer of the prostate.—*R. M Harvey.*

Randall, A. Irradiation control of testicula tumor metastases; return of renal functio after long apparent absence. *J. Urol.*, Dec 1941, *46*, 1144–1148.

Intravenous urography is of value in th study of metastasis of testicular tumors. I a study of 17 cases of testicular tumor th author has encountered 7 cases of complete un lateral anuria, indicating renal dysfunction. Th diagnosis in 6 of the 7 cases was established b orchidectomy. In all cases active irradiation wa employed and in 3 disappearance of the abdom nal mass occurred with subsequent return of th anuric kidneys to apparently normal functio Of these 3 cases 2 are alive and all of the 4 a dead in whom renal function did not retur following irradiation.

There were varied explanations for the caus of the anuria in the different cases. In the cases which terminated fatally ureteral obstru tion was present in 2, the kidney was invade by the tumor in the third and the renal vein wa invaded by the tumor in the fourth case.

Of the 3 cases in which return of functio could be demonstrated in a previously anur kidney, a late obstructive uropathy develope in one. In the other 2 the author suggests as th mechanism for the anuria renal ischem secondary to lymphatic stasis. This could r sult from an increase in intrarenal pressure.— *R. M. Harvey.*

Mertz, H. O., Howell, R. D., and Hendrick J. W. The limitations of irradiation of sol renal tumors in children. *J. Urol.*, Dec., 194 *46*, 1103–1120.

Preoperative and postoperative irradiatio is only an adjuvant to surgical removal in trea ment of kidney tumors. Apparent clinical cu have been reported following irradiation alon The authors employed roentgen radiation in th treatment of 11 renal tumors, in children. 3 of these tumors the lesion proved to be cyst at operation and irradiation had no effect on th size of the tumor. Irradiation also had no effe on a polycystic kidney. In 3 patients the tum mass became smaller but all 3 died with palpable tumor and no autopsy was permitted.

Roentgen treatment was not complete in 2 cases. Only 3 of the group with solid renal tumors had adequate irradiation and subsequent pathological diagnoses of the irradiated tumors. All cases were treated at 50 cm. with 200 kv. and a Thoraeus filter.

The first patient was a white male, aged twenty months, who had a large embryonal adenomyosarcoma which could not be adequately irradiated due to severe gastrointestinal upsets following each attempt. The few treatments given had no effect on the tumor. The dosage given is not stated by the authors.

The second case was an embryonic adenomyosarcoma of the left kidney in a male, aged eleven years. He received 2,000 r (measured in air) to an anterior and posterior portal over the kidney with daily treatments of 200 r to one portal. This gave an estimated tumor dose of 2,960 r. Three months later, 2,000 r was given to an anterior, posterior and lateral portal with an estimated tumor dose of 4,000 r. A left retrograde pyelogram at this time showed an almost normal kidney. Treatment was continued at three month intervals for a total estimated tumor dose of 9,200 r. The mass appeared to regress following the first two courses but after the third course it began to grow rapidly and the patient died fourteen months after he was first seen.

The third case of embryonic adenocarcinoma was in a male, aged twenty-nine months. This case received an estimated tumor dose of over 16,000 r. The child has survived more than three years and is apparently clinically cured.

The authors make a plea for larger dosage in these cases, continued for an indefinite period with shorter rest periods.—*R. M. Harvey.*

KREUTZMANN, H. A. R. The treatment of Hunner's ulcer with deep x-ray therapy. *J. Urol.*, Nov., 1941, *46*, 907–912.

Fulguration has proved to be the most effective method of treatment in Hunner's ulcer. The author was made aware of the value of roentgen treatment in this condition by a patient who had a Hunner's ulcer and menopausal uterine hemorrhages. Roentgen treatment of the uterine hemorrhage resulted in cure of the ulcer, which had recurred following fulguration. Five other patients in whom Hunner's ulcers recurred after other forms of treatment were subjected to deep roentgen therapy. The factors were: 200 kv. at 50 cm. tube-skin distance, with a filter of 0.5 mm. of copper and 1 mm. of aluminum. Anterior and posterior portals were used.

The usual dosage administered was 1,200–1,500 roentgens to each portal. No improvement occurred in 3 cases. In the other 3 cases complete symptomatic relief occurred together with disappearance of the ulcer for periods ranging from seven to twelve months. The author says that this compares favorably with the results from fulguration.

The dangers are possibility of producing permanent skin changes from repeated series of treatments and production of the menopause in young women.—*R. M. Harvey.*

HAUSER, HARRY. Roentgen therapy in tuberculous cervical lymphadenitis. *Radiology*, Sept., 1941, *37*, 304–309.

The treatment of choice in tuberculous cervical adenitis is roentgen irradiation combined with conservative surgery.

The author reports a series of 108 cases treated from 1932 to 1940. All types of the disease were treated. Eighty-seven of the cases were followed up for from a few months to seven years. Among these the results were satisfactory in 88.5 per cent and unsatisfactory in 11.5 per cent.

As this is a chronic inflammation small doses of irradiation should be given at comparatively long intervals over a long period of time. The author's technique was: 200 kv., 0.75 mm. copper plus 2.0 mm. aluminum filtration, half-value layer 0.9 mm. copper, 50 cm. target-skin distance, 150 r every ten days for 100 days or a total dosage of 1,500 r. With 20 ma. current the output was 35 r per minute. In bilateral lesions the dosage was 100 r on each side of the neck giving a total dosage of 1,000 r on each side. The field irradiated was larger than the involved area.

The prolongation of the irradiation prevented skin damage even if the series was repeated six months to a year later. However, a second or third repetition may injure the skin.

Two cases are described in detail to illustrate satisfactory and unsatisfactory results. In the second case in which the local results were unsatisfactory the patient's general condition was nevertheless greatly improved. She was a woman of forty who had had enlarged glands since she was fourteen years of age.—*Audrey G. Morgan.*

Kelly, James F., and Dowell, D. Arnold. Twelve-year review of x-ray therapy of gas gangrene. *Radiology*, Oct., 1941, *37*, 421–439.

The first report on the roentgen treatment of gas gangrene was made in 1931. Up to that time the mortality from that disease had been 50 per cent or more, and many amputations had been performed. In the group of 8 cases reported at that time the mortality was only 25 per cent with no removal of tissue after roentgen treatment had begun. Tables and graphs are given showing the mortality in the authors' own cases and cases collected from the literature since that time. In 364 cases with one or more roentgen treatments the mortality was 11.5 per cent; in 288 cases with three or more roentgen treatments 5.9 per cent, and in 42 cases with three or more roentgen treatments and no serum 4.7 per cent. So with roentgen treatment gas gangrene can no longer be considered a really serious disease.

The mortality was higher in cases treated on clinical evidence alone than in those in which laboratory examination showed *Cl. welchii*. That is, the inclusion of cases with doubtful diagnosis raised rather than lowered the mortality.

Amputation is not indicated in these cases. Only such tissue should be removed as is necessitated by the wound. No major surgery should be performed during the acute toxic stage for the infection itself. Nor should either serum or sulfonamides be used in conjunction with the roentgen treatment. The antitoxic action of roentgen therapy is evidently nonspecific and can be used in other infections, such as peritonitis and osteomyelitis.

Irradiation can also be used prophylactically. A number of cases are described in detail, showing the method of use and the results of the treatment.

In the discussion, Dr. McNamee objected to the use of the term prophylactic. He said that what was described as prophylaxis was really only very early treatment before clinical signs of the disease had developed. Dr. Kelly replied that what he had called prophylactic irradiation is not a vaccination but that it is prophylaxis in the sense that it prevents the infection from becoming established. In reply to a question in regard to dosage he said that they gave for treatment 150 r per day in two doses of 75 r or three doses of 50 r each to the entire abdomen or the area believed to be infected. For prophylaxis they give one dose of 75 r per day. From 90 to 130 kv. is used, depending on the thickness of the part and filtration is increased with kilovoltage.—*Audrey G. Morgan.*

Dowdy, Andrew H., and Sewell, Robert L. Roentgen radiation in experimental Clostridium welchii infection (gas gangrene) in dogs. *Radiology*, Oct., 1941, *37*, 440–442.

Experimental work in gas gangrene on small animals has been unsatisfactory because of the irregular and unpredictable course of the disease. But the authors have succeeded in producing an infection quite similar to that in man in dogs. They injected material from a twenty-four hour unwashed culture of gas bacilli intramuscularly into the thigh of the dogs. Sixty-six dogs were inoculated, 16 being used for biological standardization, 25 for the tests and 25 as controls. After the injections they were irradiated with an individual dose of 100 r (measured in air), portal from 20×20 cm. to 20×30 cm. Morphia was given in some cases to keep the animals quiet. The survival was 36 per cent among the irradiated animals and 20 per cent in the control group. The average survival period was almost twice as long in the irradiated as in the non-irradiated animals—45.4 hours as compared with 24.5 hours. The results are more striking when the factors of time between inoculation and irradiation, amount of treatment, dosage and kilovoltage are taken into consideration, and a table is given showing the effect of some of these factors. For instance in a group of animals given 1.25 cc. of the material (the lethal dose) or more, survival in the irradiated animals was 31 per cent and in the non-irradiated animals only 12.5 per cent. Further study is to be made of the effect of varying these factors and of the effect of using sulfanilamide compounds alone or in conjunction with irradiation.—*Audrey G. Morgan.*

Hodges, Fred M., Snead, L. O., and Berger, R. A. Roentgen therapy of hemangiomata. *Radiology*, June, 1941, *36*, 700–705.

Radium treatment has been quite generally used in the treatment of birthmarks. The authors find that equally good or better results can be obtained in certain types of these lesions by the use of roentgen rays. Filtered rays are used in certain selected cases of cavernous hemangiomata and contact therapy in the more

or less superficial strawberry birthmarks. Three illustrative cases are described, in the first of which a very large cavernous birthmark of the ear and face was reduced to only slight discoloration by treatment continued over thirty months. During this time the child was given 1,440 r filtered through 3 mm. aluminum at a focal skin distance of 25 cm. and at 135 kv. She was never given more than 200 r delivered in air at one treatment, more often 120 r at the rate of 40 r per minute. Contact therapy is now being used to overcome the remaining discoloration. Among 19 infants treated for strawberry birthmarks by the contact therapy method 9 have been discharged with so little discoloration that the lesion could not be located if its presence was not previously known. Of the remaining patients none has been under observation more than six months.

With contact therapy they give one treatment in four to six weeks. The dose is only of three seconds' duration, during which 400 r in air is delivered. This produces little or no reaction in the tenderest skin of the youngest infant.—*Audrey G. Morgan.*

ARONS, ISIDORE. Further studies on radiotherapy of lymphoblastoma. *Radiology*, Aug., 1941, *37*, 164–173.

In the course of the past ten years the author has treated 45 cases of lymphoblastoma, consisting of 12 cases of Hodgkin's disease, 15 of lymphosarcoma, 13 of leukemia and 5 on the borderline between leukemia and lymphosarcoma. Eight of the cases are described and illustrated with roentgenograms and the details of the roentgen treatment given in the case histories.

It has been found that normal function of the reticulo-endothelial system is a major factor in resistance to malignancy. This is particularly true in malignant disease of the lymphatic system. Therefore modern treatment of the lymphoblastomas aims to give a dosage sufficient to destroy the local lesions without injuring the reticulo-endothelial system. The massive doses that were at first given with disastrous results are no longer used. The low voltages formerly used have been increased to the present high voltages. The doses are now fractioned, the doses being given at brief enough intervals to ensure continuous radioactivity and to prevent the recovery of malignant cells not completely destroyed.

As autopsies have shown that the areas of malignant proliferation are larger than shown clinically, extensive irradiation should be used. The author thinks, however, that irradiation of the whole body should be used only in selected cases. Irradiation of the spleen—small doses over three fields—is of value in some cases of lymphoblastoma.

Experimental work has shown that involvement of the spleen is accompanied by a high percentage of involvement of the lungs.

Irradiation with small doses and short intervals is only palliative but may treble the life expectancy of the patient.—*Audrey G. Morgan.*

POPP, WALTER C., and WATKINS, CHARLES H. Roentgen therapy for chronic macrolymphocytic and mesolymphocytic lymphatic leukemia. *Radiology*, Aug., 1941, *37*, 160–163.

The authors describe what they consider a special phase of lymphatic leukemia rather than a new type of the disease. It is characterized by the fact that a large majority of the lymphocytes are of the macrolymphocytic or mesolymphatic type. At first glance the picture might be confused with that of acute leukemia but a close examination of the cells shows that they are not lymphoblasts.

Special care is necessary in the roentgen treatment of this phase of the disease as these cells are particularly sensitive to irradiation. Also irradiation with large doses is apt to bring about a rapid increase in blood urea, either from difficulty in eliminating the waste products of the destruction of leukocytes or from involvement of the kidney itself. Too great reduction of the number of leukocytes should also be avoided. When the count is around 75,000 reduction to 25,000 to 30,000 is sufficient and proportionate reduction with other counts.

They give not more than 100 to 125 r per field with about 130 kv. Only one treatment is given per day and they are continued daily until the count has reached the desired level. Frequent leukocyte counts and blood urea determinations should be made.

Dr. Haden said be believed the disease described was more closely related to sarcoma than the classic lymphoid leukemia. Such cells are sensitive to irradiation. Dr. Portmann said he believed he had not made a special classification of the type of leukemia described. He has, however, given roentgen treatment to patients in the leukopenic stage of leukemia with good

results. In these cases he gives spray irradiation anteriorly and posteriorly in small doses—25 to 50 r—on alternate days. He has had bad results in only 1 case in which an overdosage was given. Dr. Newell said he believed in giving the smallest dosage that gives results in all cases of leukemia. He generally starts with a dosage of 25 r rather than 100 r. He does not understand the authors' fear of a low white count. Even if the count goes down to 6,000 it is not alarming if this fall has been brought about by small doses of irradiation. Dr. Popp in closing said there is probably no disease in which there is greater confusion in classification than in leukemia. He believes the type described by him and his colleagues is a distinct entity and should not be confused with leukosarcoma.—*Audrey G. Morgan.*

Jacox, Harold W., and Freedman, Lester J. The roentgen treatment of myxomatous cutaneous cysts. *Radiology*, June, 1941, *36*, 695–699.

The authors describe 7 cases of myxomatous skin cysts seen at the Western Pennsylvania Hospital in the course of three years. This incidence in an active dermatological service shows that these cysts are not very frequent. They were formerly confused with synovial lesions of the skin but the differentiation should be made as surgery is effective in the latter while the myxomatous cysts are apt to recur after surgical removal.

These cysts are caused by degenerative changes in the corium, the etiology of which is not known. They are not reducible by pressure as the synovial cysts are and as they are a part of the corium the skin cannot be moved over them. They are best treated by low voltage roentgen therapy, 100 kv. constant potential, 4 ma., 30 cm. focal skin distance, no added filtration, 120 r per minute, 1,400 to 1,600 r at one treatment. The field should be limited to the base of the lesion and the surrounding skin adequately protected. The doses formerly used were too small to be effective.—*Audrey G. Morgan.*

Cipollaro, Anthony C. Irradiation in dermatology. *Radiology*, June, 1941, *36*, 684–694.

There is a great lack of uniformity in the technique of irradiation in skin diseases. In general, roentgenologists tend to use higher voltages, greater filtration, larger doses and shorter intervals between treatments while dermatologists use lower voltages, little or no filtration and smaller doses with longer intervals. Certainly the quality of rays should be used which gives the best results with the least damage to underlying structures. A chart is given which shows absorption curves with depth doses of various radiations used in dermatological practice superimposed, with correct dimensions, over a cross-sectional diagram of the skin. The peak voltages varied from 40 to 140 kv. It shows that for routined ermatologic treatment unfiltered roentgen rays generated with 40 kv. are as effective as those generated with 100 kv. Certainly 100 kv. rays are more than adequate to reach pathological lesions in the skin. In support of his thesis that high voltage heavily filtered rays are unnecessary and even undesirable in dermatologic practice the author discusses the treatment of a number of the commoner skin diseases.

In the discussion Dr. Driver said that the less irradiation given consistent with good results the better. Nor should irradiation be repeated too often for such diseases as acne vulgaris, particularly in young people less than seventeen or eighteen years of age. The need of a complete knowledge of the treatment used was also emphasized.—*Audrey G. Morgan.*

Ashbury, Howard Hicks. An ointment for the relief of discomfort due to severe irradiation epidermitis. *Radiology*, June, 1941, *36*, 739.

In the ordinary skin reaction caused by irradiation the discomfort can be controlled by aquaphor. But the author describes a case of severe reaction from irradiation of cancer of the vulva. This is a particularly sensitive area and the skin and mucous membrane were completely denuded. Relief was obtained by the local application two or three times within twenty-four hours of an ointment made by the addition of 0.5 to 1 per cent of tetracaine to the aquaphor.—*Audrey G. Morgan.*

Roberts, Ff. The limitations of biopsy in x-ray therapy. *Brit. J. Radiol.*, April, 1941, *14*, 144–145.

There has been an increasing tendency on the part of radiologists to demand biopsy examinations before giving treatment. The author believes that this tendency has been exaggerated

and that, if there are clinical and roentgenological evidences of malignancy, treatment should be given without waiting for a pathological examination. In the first place, the patient is apt to be very sick and should not be subjected to additional unnecessary strain. Then there is the possibility that a malignant growth may be disseminated. Biopsy often does not give a definite result; the part of the growth that is removed may be non-malignant but there may be malignancy in other parts. The course of the treatment cannot be influenced by the finer degrees of microscopic malignancy.

Some radiologists evidently fear that if histological diagnosis is not made and a cure results discredit will be cast on their treatment on the ground that the diagnosis was incorrect. But the fact that malignant growths can be cured by irradiation has been sufficiently proved so that histological evidence is not necessary in every case.—*Audrey G. Morgan.*

Jacoby, Paul, and Spotoft, J. Investigations into the significance of the sedimentation reaction as regards the prognosis of irradiation of cancer patients. *Radiology*, May, 1941, *36*, 617–620.

This report is from the Radium Center of the Danish Society for the Campaign against Cancer in Odense, Denmark. This country is so small that it is much easier to follow up cancer patients than in larger countries. The author reports 59 cases of cancer of the breast and 39 with cancer of the uterus in which sedimentation tests were made before treatment and afterwards at varying intervals. Tables are given showing the details of the results.

The prognostic significance of the sedimentation reaction cannot be judged until about a year after the beginning of treatment. The figures for both groups of cases show that increased sedimentation reaction has an unfavorable prognostic significance. The use of the sedimentation reaction in the control of cancer patients should be continued.—*Audrey G. Morgan.*

MISCELLANEOUS

Lindgren, Erik. An apparatus for radiography in immediate connection with radioscopy. *Acta radiol.*, 1941, *22*, 383–386.

The author describes and illustrates an apparatus for taking roentgenograms in immediate connection with screen examination of the duodenum. In this way no changes take place in the condition of the organ between the time of the fluoroscopic examination and the making of the permanent record. It is so arranged that it can be switched from the screening side to the exposure side by the nurse at a given signal from the doctor. Many similar devices have been used before but the author thinks his is simpler, lighter and less expensive than most of those in use heretofore.—*Audrey G. Morgan.*

Clark, K. C., and Poulsson, K. T. Further experiments in x-ray screen photography (1011 subjects with control direct radiographs). *Brit. J. Radiol.*, July, 1941, *14*, 250–254.

Miniature screen photography and comparative direct roentgenography was carried out in 1,011 cases, 771 of the subjects being Norwegian seamen escaped from the Lofoten Islands in March, 1941; they were of outstanding physique. The others were students, office workers, factory hands, etc. The details of the screen photography are discussed and a table given showing the findings in the 55 cases in which there were pathological conditions.

Two physicians examined the miniatures and control direct roentgenograms. The less experienced of these found 11 discrepancies and the more experienced 10. The discrepancies found were of no clinical significance. Evidently if first-class technique is used screen photography very closely approximates if it does not equal the results of the usual direct method in distinguishing the normal from the pathological. Definite active tuberculous lesions were found in 13 of the cases, including 2 of pleural effusion. None of these lesions were overlooked in the miniatures.—*Audrey G. Morgan.*

Hodes, Philip J., and Griffith, John Q. Effect of roentgen irradiation upon lymphatic flow in rats. *Radiology*, Aug., 1941, *37*, 203–204.

Rats were irradiated to determine whether roentgen irradiation has any effect on the flow of lymph. Two groups were treated—one with 135 kv., 4 ma., 0.25 mm. copper plus 1 mm. aluminum filtration, 30 cm. target-skin distance, total dose to skin 2,250 r (in air) given at one time in about forty minutes. Twenty-one to twenty-five days later thorotrast was injected into the dorsum of each foot. One hind leg of each rat had been irradiated while the other was used as a control. The other group was treated

with 200 kv., 20 ma., 0.75 mm. copper plus 2.0 aluminum filter, 25 cm. target-skin distance, total dose 2,200 r in air delivered at one time in about twenty minutes. Injections of thorotrast six weeks after irradiation.

In neither group was there any appreciable interference with the flow of lymph. But much more experimentation is necessary before these results can be applied to human problems. Different daily doses and a much wider range of time interval after irradiation must be used. Possibly colloid dye studies would be more effective in determining the rate of lymph flow.—*Audrey G. Morgan.*

Glücksmann, A. Preliminary observations on the quantitative examination of human biopsy material taken from irradiated carcinomata. *Brit. J. Radiol.*, June, 1941, *14*, 187–198.

The biological response of both normal and malignant cells to radiation has been studied quantitatively at the Strangeways Research Laboratory, Cambridge. In this paper a method is described by which the effects of radiation on living malignant cells in biopsy material is measured quantitatively. The method so far has been applied only to the primary growth in squamous and basal cell carcinomata. Biopsies were taken before treatment and at different intervals during and after treatment. They were cut at right angles to the surface of the tumor so as to include the growing edge and both malignant and normal tissue.

All the cells in selected young areas of tumor growth were counted and divided into four classes: dividing, degenerate, resting, and differentiating cells. Graphs are given showing the percentages of these different types of cells at various times during and after the treatment. The resultant curves can be used somewhat as blood counts are used in blood diseases for determining the response of the tumor to treatment. The effectiveness of the treatment can be judged by the quantitative differences in the different types of cells in counts made at the different periods. The method is to be tested on a larger scale.—*Audrey G. Morgan.*

Sugiura, Kanematsu. The effect of high and low body temperatures upon the growth of irradiated mouse sarcoma 180. *Radiology*, July, 1941, *37*, 85–93.

The author believed that the growth of mouse tumor might be affected by the body temperature of the animals. The experiments which he performed in the attempt to settle this question are described in detail and illustrated. Fever was brought about by the use of short and ultra-short radio waves, cold by keeping the animals in the refrigerator. Mouse sarcoma 180 was used for the experiments.

When animals with tumors were irradiated with 200 kv. and then subjected to ultra-short radio waves until the rectal temperature was 40° to 43° C. the number of tumor regressions was definitely increased. With doses of 1,000 r the regressions increased from 50 to 75 per cent.

When the temperature at which the irradiated mice was kept was reduced to −10° C. the animals all died within a few hours. When they were kept at temperatures of 3° to 5° C. they survived but the number of tumor regressions was decreased. With a dose of 100 r the decrease was from 50 per cent to 27 per cent.

A study was also made of the resistance of mouse sarcoma 180 to cold in vitro. Bits of tumor tissue were kept at −70° C. for varying periods and then inoculated into normal mice. The capacity of the tumors for growth was only slightly inhibited by this procedure. The growth of the tumors was greatly delayed for the first week but after that it was normal. It made no difference whether the tumor fragments were kept for one hour or for seven days in the frozen state. The injurious action of the cold on the tumor cells was due to the initial rapid freezing and not to keeping them frozen for long periods. —*Audrey G. Morgan.*

Denstad, Torfinn. Die Strahlensensibilität des Knochenmarks. (The radiosensitiveness of the bone marrow.) *Acta radiol.*, 1941, *22*, 347–359.

The animal experimentation which has been done on the effect of irradiation on the blood has not given uniform results and besides the findings cannot be applied to human pathology. The author has therefore studied the action of irradiation, both radium and roentgen, on the bone marrow in human subjects being treated for cancer. The roentgen treatment as a rule was given with hard rays—175 kv., 4 ma., 2 mm. copper and 3.5 mm. aluminum filter, 60 cm. distance. Material for examination was obtained by puncture of the sternum.

It was found that the red marrow is very sensitive to irradiation. Marked changes took place even after the small doses used in the treatment

of inflammation and arthrodesis. Both the erythropoietic and the myopoietic cells were affected, the most immature cells being the ones that disappeared quickest. The bone marrow showed a very great capacity for regeneration. Even with the largest therapeutic doses there was almost complete anatomical regeneration after one to a few months. But the blood changes were more persistent. A marked leukopenia, chiefly lymphopenia, sometimes persisted for a year after treatment, though the general health was not affected. This leukopenia is doubtless due to the inhibiting action of the irradiation on myelopoiesis and lymphopoiesis. This inhibition is evidently due to a distant action of the rays and occurs whether the marrow is irradiated directly or not. Total irradiation is probably the best palliative treatment for leukemia.—*Audrey G. Morgan.*

FRIED, CARL. The roentgen treatment of experimental pneumonia in the guinea-pig. *Radiology*, Aug., 1941, *37*, 197–202.

It has been found empirically that roentgen irradiation in pneumonia brings about decline of the fever, disappearance of dyspnea, general improvement and shortening of the course of the disease.

The author experimented on the irradiation of artificial pneumonia in guinea pigs in an attempt to account for this improvement and to determine whether it could be counted on in all cases. The animals were infected by giving them an intratracheal injection of an emulsion of *Staphylococcus aureus haemolyticus*. Less than lethal doses were given so that the controls could be used for purposes of comparison. The irradiated animals showed the same clinical improvement as human subjects. Macroscopically the lungs of the non-irradiated animals showed hepatization while those of the irradiated animals were soft and normal in color and consistency. Histological examination showed infiltration in the non-irradiated animals and normal alveoli in the irradiated ones. Obviously irradiation hinders the development of pneumonia and the earlier it is given after infection the better the results.

The course of the experimental pneumonia in animals is fundamentally the same as that of postoperative pneumonia in man and the author concludes that the results of irradiation seen in human cases have not been due to chance but to the power of irradiation to limit inflammation and influence the mechanism of healing.—*Audrey G. Morgan.*

CHAMBERS, ROBERT, and CAMERON, GLADYS. The reaction of kidney tubules in tissue culture to roentgen rays. *Radiology*, Aug., 1941, *37*, 186–193.

These experiments were made with a view to determining whether cells when physiologically active are more susceptible to the action of roentgen rays than when they are not. The tissue used was from the mesonephros of nine or ten day chick embryos grown in tissue culture. Experiment has shown that these tubules continue to function in tissue cultures. The outgrowth from the explant consists of wandering cells, fibroblasts and sheets of proliferating epithelium so that the cultures provide a method of studying epithelial tissue as organized tissue in the form of secreting tubules and as unorganized tissue in the form of outgrowing sheets.

It was found that organized secreting tubules and wandering cells were far more sensitive to the action of the rays than unorganized epithelial sheets. The distal tubules were found to be more radioresistant than the proximal tubules.

Doses of 5,000 to 75,000 r were used. Large doses of 25,000 r were required to bring about definite effects within several days.

The results of the experiments show that cellular activity is a factor in increasing the susceptibility of cells to the destructive action of irradiation. The susceptibility of the tubules was increased when their secretory activity was stimulated by the addition of phenol red or magnesium sulphate to the medium.

The renal cells are capable of recovering from the effects of sublethal doses of irradiation, as shown by the fact that if they are stimulated to secrete soon after irradiation they die, but if time is allowed for them to recuperate they can do the extra work required by the stimulation without deteriorating.—*Audrey G. Morgan.*

HENSHAW, PAUL S. The induction of multipolar cell division with x-rays and its possible significance. *Radiology*, June, 1941, *36*, 717–724.

There is apparently a paradox in the fact that irradiation causes cell death and yet may also cause the unrestrained growth of cancer.

When fertilization takes place the fertilized egg practically always divides into two equal blastomeres but if either of the gametes is ir-

radiated before fertilization takes place cleavage takes place not into two blastomeres but into several. This multipolar cell division usually causes early death of the cell progeny. There is as yet no record of multipolar division actually having caused tumor but it seems possible that it may cause changes in hereditary substances which make malignant growth possible. Experimental work has shown some interesting facts bearing on this problem. If young mice from a high-breast-cancer strain are foster-nursed by mother from a low-cancer strain few cancers will develop among them, but if the young of low-cancer strains are nursed by mothers of high-cancer strains there will be many cancers. This indicates that there are two factors in the causation of cancer—one in the hereditary background and one in the milk. Possibly radiation acts as the stimulating factor that rouses into activity certain hereditary factors capable of causing malignancy.—*Audrey G. Morgan.*

Westermark, Nils. A study of the cardiac movements simultaneously recorded by roentgen-cinematography and electrocardiography. *Acta radiol.*, 1941, *22*, 393–403.

The author describes experiments made on sheep which show how complicated the movement of the heart is, not only during the active phase of systole but also during the passive phase of diastole. Five metallic indicators were inserted into the wall of the left ventricle and roentgen cinematography and electrocardiography carried out at the same time. By the method used, which is described, the records of the two methods of examination could be compared with an accuracy of 1/18 to 1/24 second. Diagrams are given of the position of the indicators in the wall of the ventricle and graphs show the paths of the indicators during the revolution of the heart.

They show that the anterior part of the base of the ventricle makes a piston-like movement with the downward phase at the beginning of diastole and the upward movement during the end of systole. The anterior part of the base of the ventricle remains perfectly quiet during diastole. Apparently, therefore, a contraction of the rest of the wall of the ventricle has taken place during systole. Except for a tendency of the wall of the ventricle to approach the base of the heart, no contractile movement of this kind could be demonstrated definitely on the outlines of the wall of the ventricle. These outlines seemed to describe a pendulum-like and rotatory movement caused by the movements of the whole heart.—*Audrey G. Morgan.*

Taylor, Lauriston S. New x-ray laboratory of the National Bureau of Standards. *Radiology*, July, 1941, *37*, 79–84.

During the past ten years the voltage of roentgen treatment apparatus has been increased from 200 kv. to about 1,000 kv. The problem of the establishment of suitable standards for such voltages has been turned over to the Bureau of Standards and a laboratory has been built for this purpose at a cost of about half a million dollars. This laboratory and its equipment is described in detail and a floor plan of the first floor and roentgen-ray laboratory given. The space is divided about equally between the roentgen-ray section and the high-voltage measurements section. The building is five stories in height. At the time this article was written the installation of the 1,000 kv. equipment had been completed and the equipment was in operation. The 400 kv. equipment on the second floor had just been completed and standardization work was to be begun.—*Audrey G. Morgan.*

Cassen, Benedict. Some recent contributions of physics and engineering research to radiology. *Radiology*, Sept., 1941, *37*, 338–342.

The author pays tribute to the great value of the work of physicists and engineers in the progress of radiology. He discusses a number of recent contributions, among them ignition timing, air cooling for therapy tubes, the polarized stereoscope, which makes it possible for a number of observers to obtain stereoscopic vision of roentgenograms at the same time, and the substitution for the old feathered copper-glass seals of Kovar-glass seals. The technical details of these discoveries are described and illustrated with diagrammatic drawings. They are all contributions to roentgenography except the air cooling of therapy tubes which is of value in treatment.—*Audrey G. Morgan.*

Stanford, Brian. A research into the physical factors concerned in indirect radiography. I. The optimum combination of film and fluorescing screen for use in indirect radiography. *Brit. J. Radiol.*, April, 1941, *14*, 128–135.

Indirect roentgenography, or the photo-

graphing of the image made on the fluoroscopic screen, has not been very widely used practically in England. The author therefore proposes to consider in a series of papers the various physical factors involved in the process. In this paper he considers the effect on density of the image of different combinations of photographic emulsion and fluorescing screen. Eleven emulsions and five screens were tested in all possible combinations with regard to their effect on density, the other factors being kept constant. The technique of the experiments is described and tables given showing the details of the results. One table shows the results obtained for the three most effective screens and various emulsions that can be obtained commercially.

Of course under a different set of conditions with regard to the roentgen-ray beam these findings might be changed.—*Audrey G. Morgan.*

STANFORD, BRIAN, A research into the physical factors concerned in indirect radiography. III. A simple method of detecting experimentally the presence of the phenomenon of latent image reinforcement in a fluorescing screen. *Brit. J. Radiol.*, June, 1941, *14*, 213–214.

With some fluorescing screens a subject previously recorded may reappear when the screen is used again, appearing as a ghost image that confuses the clarity of the second image. This is permissible to some extent in recording screens as the phenomenon persists for only a short time and they are rarely used twice at such short intervals. But in mass roentgenography the image on the screen may be changed every few seconds and so such reinforcement is not permissible.

A simple method of testing a screen for this phenomenon is described. Exposure is made on the screen of a steep roentgen-ray step-wedge, which is then rotated for 90° and a second exposure made. If there is no latent image reinforcement, only the second image will appear on the screen. Screen G 231 was tested in this way and found free of the phenomenon.—*Audrey G. Morgan.*

STANFORD, BRIAN. A research into the physical factors concerned in indirect radiography. IV. The quantitative estimation of the actinic value of the afterglow of a fluorescing screen. *Brit. J. Radiol.*, July, 1941, *14*, 244–246.

The details of an experiment performed to make a quantitative determination of the actinic value of the afterglow of a fluorescing screen are described. A G 231 200-mesh screen was used. The screen was activated regularly every ten seconds for a tenth of a second at 80 kv., 100 ma., 2 ft., 3 in. tube-screen distance. Under these conditions the useful actinic emission becomes negligible about two seconds after activation is discontinued. If a screen is used that has an afterglow a simple shutter should be used in the camera. If the viewing screen has no detectable visual afterglow it may be assumed to have no actinic afterglow and in that case a shutter is not necessary.—*Audrey G. Morgan.*

STANFORD, BRIAN. A research into the physical factors concerned in indirect radiography. V. The effect on luminous output of variation of crystal size of the fluorescing material. *Brit. J. Radiol.*, Sept., 1941, *14*, 304–306.

The fluorescence of fluorescent screens is often accompanied by phosphorescence in which the emission of luminous energy persists after the exciting radiation has stopped. This is very undesirable as in viewing screens it leaves the trace of moving organs on the screen and blurs the image. On recording screens the imprints of former exposures are left superimposed on more recent ones.

This article describes tests made to see to what extent variations of the mesh size, that is the size of the crystals constituting the salt coating, would affect the intensity of the light emitted by the screen. Five screens were tested which were specially prepared from two salt mixtures; three from salt G 231 passed through sieves of 120, 200 and 220 mesh and two from salt Y-S passed through sieves of 120 and 200 mesh. The variations in mesh size had no effect on the luminosity of salt Y-S. Mesh 200 was optimum for salt G 231, while 220 was about 10 per cent slower than this and 120 about 30 per cent slower. Increased kilovoltage resulted in proportional increase in luminosity on both screens to an equal degree throughout the range tested. The fluorazure salt, ordinarily used as a recording screen, shows an optimum response at 65 kilovolts.—*Audrey G. Morgan.*

WILLIAMS, MARVIN M. D. The effect of shockproof cables and condensers on two-valve half-wave rectification. *Radiology*, July, 1941, *37*, 94–101.

Changes in the equipment for roentgen therapy in the past few years have given an opportunity to compare the quantity and quality of radiation produced by several types of rectifying circuits and particularly for determining the effect of shock-proof cables and condensers on two-valve half-wave rectification.

A series of oscillographic tracings is given for different milliamperes at several peak voltages, showing the effect of the capacity of shockproof cables and condensers on the voltage waveform from a two-valve half-wave rectifier. These different voltage wave forms cause changes in the intensity and quality of the radiation. A change of more than 100 per cent in the number of roentgens per minute per milliampere, as well as changes in the quality of the radiation may be brought about by shockproof cables, the presence or absence of other condensers and different tube currents.—*Audrey G. Morgan.*

Jacobs, Lewis G. The accuracy of focal spot size determination: some theoretical and practical considerations. *Radiology*, Aug., 1941, *37*, 214–220.

The author gives mathematical formulae for estimating the effective projected focal spot distance for clinical use without further correction, provided the tube is centered between two pinholes with its principal axis perpendicular to the line connecting the pinholes and provided the target-pinhole distance is large both absolutely and in proportion to the distance between the pinholes. As the measurement of the shadows on the film is subject to quite a large error it is best to use the average of at least ten different measurements for the values both of shadow size and of the distance between the shadows. The method is not accurate to more than 5 per cent though it is possible that its accuracy might be improved by special camera construction, especially if extra fine grain film and extremely small pinholes were used to decrease the penumbra.—*Audrey G. Morgan.*

Glasser, Otto. The evolution of dosimeters in roentgen ray therapy. *Radiology*, Aug., 1941, *37*, 221–227.

The older methods of roentgen dosimetry are described. In 1925 a Committee on Standardization of Measurement of Radiation was formed by the Radiological Society of North America. It was made up of radiologists and physicists as the importance of collaboration between these two groups was realized.

Roentgenologists are interested primarily in the average quality of the roentgen-ray beam used in treatment and its distribution in the tissues. Therefore they prefer some way of specifying quality according to absorption values. Total absorption curves in any absorbing medium can be made easily with modern ionization dosimeters, and those of constant potential apparatus have a close relationship to the spectral distribution of the radiation. Taylor in 1938 developed standard absorption curves to be used as practical "qualimeters." Absorption coefficients, effective wave lengths, average wave lengths and half-value layers can be derived easily from such absorption measurements. The preferred way of expressing quality is according to half-value layer.—*Audrey G. Morgan.*

Meyer, William H. Depth dose calculation wherein absorption in unit volume in the depth, i.e., volume depth dose, is the index of effective radiation. *Radiology*, Oct., 1941, *37*, 476–486.

The author maintains that the r dose, usually taken as the unit of dosage, varies with the voltage or filtration used, with the size of the field, the focal distance and the r per minute of application of the dose. The important thing is to bring about maximum absorption at the site of the lesion. He presents the scale of a depth dosimeter that he has worked out on the basis of many years' experience in the use of radiation therapy. It allows for the variable factors and permits of a rapid determination of depth dosage.—*Audrey G. Morgan*

Lamerton, L. F. Physical investigations with 140 kVp radiation. *Brit. J. radiol.*, June, 1941, *14*, 199–205.

Physical examinations have been made of low voltage radiation, up to 60 kv. and in the higher ranges from 180 kv. up. But very little work has been done on the intermediate range which is known as that of middle distance therapy. The author describes measurements made at 140 kv. (peak) using a Victor middle distance set. Absorption measurements were made in copper, using a Victoreen condenser dosimeter. The tube filters used were 0.25 mm. copper and 0.10 mm. copper. The half-value layers and equivalent wave lengths with these filters are

given and the absorption curve shown. Measurements of the variation of depth dose with variations in filtration showed that 0.25 mm. copper was a good filter for use in treatment. The variation of percentage backscatter with variations in the size of field was measured. Central axis depth dose curves for different field sizes and with focus-skin distances of 15.5, 20 and 25 cm. are given, as well as some complete isodose curves. Measurements of the stray radiation near the tube are also described.—*Audrey G. Morgan.*

REINHARD, M. C., and GOLTZ, H. L. Note on the distribution of surface radiation from a million-volt generator. *Radiology*, Sept., 1941, *37*, 335–337.

The million-volt roentgen-ray generator of the type installed at the State Institute for the Study of Malignant Disease at Buffalo in June, 1940, has two beams, one transmitted and one reflected. The target is placed at an angle of 45° to the long axis of the tube which results in a differential filtration of the radiation of the transmitted beam, with a consequent asymmetry of intensity. This asymmetry can be corrected by the introduction of wedge-shaped filters of copper or lead. These are simple and easily made and can be changed if necessary.—*Audrey G. Morgan.*

FLINT, H. T., and WILSON, C. W. The homogeneity of dosage distribution in radiation teletherapy. *Brit. J. Radiol.*, Sept., 1941, *14*, 300–303.

In securing homogeneity of irradiation in the treatment of tumors with radium the method should be to provide some form of framework with the irradiation portals and central directions indicated. The field within the framework is then known and the patient must be placed so that the lesion lies in the most suitable part of the field. The principle is to place the patient within the field, not to form the field within the patient.

Such a framework or jig, designed for the treatment of tumors of the larynx is illustrated and a diagram given of the distribution of radiation resulting from three teleradium fields fixed to the jig. This arrangement provides for homogeneity of distribution of the radiation and ensures that all the diseased tissue is given adequate treatment.—*Audrey G. Morgan.*

CLARKSON, J. R. A note on depth doses in fields of irregular shape. *Brit. J. Radiol.*, Aug., 1941, *14*, 265–268.

Depth doses have been worked out quite accurately for circular or square fields. But occasionally very irregularly shaped fields are used in treatment. A method of calculation is given for percentage dose rates at any point within a volume of tissue which is irradiated from a beam of roentgen or radium rays, no matter what the shape of the field. Results of the calculation of central axis depth doses for rectangular fields are also given. Tables and graphs show the details of the results.—*Audrey G. Morgan.*

MAYNEORD, W. V., and LAMERTON, L. F. A survey of depth dose data. *Brit. J. Radiol.*, Aug., 1941, *14*, 255–264.

In working out the depth dose tables that are given at the end of this article, the authors surveyed the results of a number of other workers. These are apt to be more reliable than individual measurements made with inadequate apparatus. They concluded that sufficiently accurate tables could be drawn up not only for the 200 kv. region but also for the higher regions up to 1 million volts. The mathematical equations used in working out their results are given and the graphs showing the details of the results. The three most important factors considered were the focal-skin distance, the quality of the radiation and the area of the field. The tables give the percentage depth dose for qualities of radiation from 1.0 to 5.0 mm. copper half-value layer at depths up to 20 cm. for fields up to 400 sq. cm. in area and with focal-skin distances from 40 to 100 cm. A less comprehensive study has been made of radiation up to 17 mm. copper half-value layer and the results are shown in curves and tables. The mean values of percentage surface backscatter have been determined from the literature for fields up to 400 sq. cm. in area and for qualities up to 14 mm. copper half-value layer. A discussion is also given of the variations in half-value layer with variations in conditions of radiation.—*Audrey G. Morgan.*

HAPPEY, F. The integration of radiation dosage and the absorption of energy in tissue for X and gamma radiation. *Brit. J. Radiol.*, July, 1941, *14*, 235–241.

At the Sheffield Radium Center the general plan is to give a uniform tumor dose of between

4,000 and 6,000 r. In deep-seated lesions a multiple field technique must be used to accomplish this and as a result much radiation is absorbed not by the tumor but by the normal tissues. The determination of this absorption is of great clinical importance. The methods of calculation for determining it at the Sheffield Radium Institute are given as well as curves and tables showing the details of the results. The calculations are made for 200 kv. radiation with a filter of 1 mm. copper and 1 mm. aluminum and fractional integrated dosage curves are given for these conditions. Corrections must be made for fields larger than 150 sq. cm.

The graphs given presuppose that all radiation is absorbed and the formulae given are not applicable to glancing fields, for which adjustments must be made.—*Audrey G. Morgan.*

TING, T. P. A simple calculator for roentgenographic mensuration. *Radiology*, Aug., 1941, *37*, 208–213.

The author from the Department of Radiology, Peiping Union Medical College, reports a calculator for measuring the size of head or pelvis that is simple, accurate and inexpensive. It determines the object size (X) when the target-film distance (H), the object-film distance (L) and the size of the image (a) are known. The calculator is essentially a chart consisting of two superimposed plots; one is rectangular, dealing with the relationship of the target-film distance H and the object-film distance L, while the other is a polar graph of the object size, X, on a family of circular arcs indicating the various sizes of the image a. Actually the circular plot is replaced by a movable radial member which is pivoted on one end to the polar origin. A half-size reproduction of the chart is given. The mathematical formulae used in constructing the chart are also given.

To use it, first find the point where the target-film distance used intersects the object-film distance measured. Swing the radial member which is pivoted on one end to the origin, until its lower edge coincides with the point of intersection. Then on this radial member mark a point corresponding to the size of the image measured. Finally, by noting the curve on the chart which meets this point on the radial member and tracing it downward until it intercepts the horizontal axis the size of the object is obtained from the appended table. The table also gives the volume of a sphere corresponding to given measurements of diameter or circumference.—*Audrey G. Morgan.*

MARINELLI, L. D. Milliammeters at ground potential in x-ray tube circuits. *Radiology*, Sept., 1941, *37*, 331–334.

In modern roentgen-ray equipment the milliammeter is usually at ground potential. But this has been brought about in two old roentgen-ray machines without making any expensive modifications. The two types of machine and the methods used to bring about the desired change are described and illustrated with diagrammatic drawings.—*Audrey G. Morgan.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 MAY, 1943 No. 5

CONTENTS

A Critical Analysis of the Roentgen Signs of Infantile Scurvy . . . . . RALPH S. BROMER, M.D. 575

Calcification of Renal Tumors . . . . GEORGE AUSTEN, JR., M.D. 580

Roentgenologic Examination of the Pharynx SIEGFRIED W. WESTING, M.D. 587

Post-traumatic Necrosis of Bone . . . . . RAYMOND W. LEWIS, M.D. 593

Extraordinary Calcification in the Breast . . . . . BENJAMIN W. ANTHONY, M.D., AND HERBERT C. POLLACK, M.D. 600

Osteopoikilosis: A Case Report . ROY H. THOMPSON, LIEUTENANT COLONEL, M.C., REUBEN HOOVER, MAJOR, M.C., AND HUSTON F. FULTON, M.D. 603

The Roentgen Treatment of Cancer of the Esophagus . . . . . D. W. SMITHERS, M.D., D.M.R., J. R. CLARKSON, PH.D., ... AND J. A. STRONG, M.SC. 606

Roentgen Therapy of "Virus" Pneumonia ALBERT OPPENHEIMER, M.D. 635

Radiation Hazards during Roentgenoscopy. THOMAS N. WHITE, PH.D., . . . DEAN B. COWIE, B.S., AND ALFRED A. DE LORIMIER, M.D. 639

Protective Features Provided with the United States Army Field Roentgenoscopic Equipment . . . . . ALFRED A. DE LORIMIER, M.D., ... DEAN B. COWIE, B.S., AND THOMAS N. WHITE, PH.D. 653

Studies on the Indirect Effect of Roentgen Rays in Single and Parabiotic Mice . . . . . W. A. BARNES, M.D., AND O. B. FURTH, M.D. 662

An Investigation into some Practical Aspects of Roentgen-Ray Stereoptics . . . . . EDWARD KLEIN, D.D.S., MILTON KLEIN, D.D.S., ... HAROLD KLEIN, D.D.S., AND ALLEN T. NEWMAN, M.D. 682

Editorials

Pyelograms in Essential or Hormonal Hypertension 692

Edward George Meter, 1876–1943 694

Society Proceedings, Correspondence and News Items 696

Book Reviews 700

Books Received 702

Abstracts of Roentgen and Radium Literature 704

GENERAL INFORMATION

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publisher.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 MAY, 1943 No. 5

A CRITICAL ANALYSIS OF THE ROENTGEN SIGNS OF INFANTILE SCURVY*

By RALPH S. BROMER, M.D.
Bryn Mawr Hospital
BRYN MAWR, PENNSYLVANIA

IN THE years which have passed since the discovery of the roentgen rays, diagnostic roentgenology has broadened to include many diseases. This is especially true in those pathological conditions affecting the skeleton in infants and children. It is well to review occasionally in critical fashion the accumulated diagnostic criteria in the literature of a subject and to retain that which withstands close and studious scrutiny and reject premises and conclusions found to be untenable in the light of clinical experience and investigative results. With this intent I have chosen to review, briefly, the roentgen signs of infantile scurvy. It is now fifteen years since I first reported the study of a series of 56 cases of this condition in a paper presented before this Society.[1] I attempted then to enumerate the roentgen signs of infantile scurvy and to arrange them in sequence so that four stages would show the progress of the disease as demonstrated in the roentgenogram. This was done with the purpose in mind of making the diagnosis less difficult for the roentgenologist and to lay emphasis on the diagnosis in early stages before the subperiosteal hemorrhages could be demonstrated.

The four stages described were, briefly, as follows:

First Stage. In the roentgenogram the changes present the smooth, transparent, ground glass appearance of the shafts, especially near the ends of the diaphyses; the dense zone of temporary calcification at the end of the diaphysis; the thinning of the cortex, sometimes called the "pencil point atrophy" and the dense ring about the epiphyseal center with the ground glass appearance of the cortex within it, similar to that shown in the diaphysis.

Second Stage. In this stage the zone of decreased density appears behind the zone of temporary calcification caused by the framework marrow zone, or the Trümmerfeldzone, or the scurvy zone, as it has been variously designated. In addition to this the first roentgenographic sign of hemorrhage beneath the periosteum may appear as shown by the formation of lateral spurs which project usually at right angles to the extremity of the diaphysis on either the outer or inner sides in the anteroposterior view.

Third Stage. Well developed subperiosteal hemorrhages are shown in this stage

* Presidential Address delivered at the opening of the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

with the density of beginning calcification within them. The so-called epiphyseal separations occur most often in this stage. Barlow pointed out that these lesions should not be regarded as true separations of the epiphysis since the line of cleavage is not at the diaphyso-epiphyseal junction but involves the very limit of the diaphyseal extremity and they actually are infractions or fractures of the shaft.

Fourth Stage. In this stage the repair of the scorbutic lesions with absorption of the subperiosteal hemorrhages takes place. Progressive decrease in the breadth and length of the hemorrhages can be seen if serial examinations of the patients are made. But the roentgen signs of hemorrhage as shown by periosteal thickening can persist long after the clinical signs have abated and healing has begun. Other signs of healing are intensification of the zones of temporary calcification, gradual disappearance of the zones of rarefaction and increase in width of the dense ring surrounding the epiphyseal center. Some observers believe that the central area of ground glass texture remains stationary while the surrounding ring or zone becomes denser and broader as the epiphyseal centers increase coincidentally with the normal growth of the child's extremities. This small central area may persist for several years.

The fact was emphasized that if therapy is begun before subperiosteal hemorrhages are demonstrated in the roentgenograms the progression is from the two early stages to the final or healing stage without the occurrence of the third.

Does further experience and investigation as reported in the literature confirm such a classification into stages or is it unwarranted? Are the signs, enumerated as early signs, to be regarded as actual early signs of the disease as measured by the time of clinical recognition and diagnosis?

Dempster[3] in his small volume entitled "Medical Writing" quotes Graham Wallas who wrote of what he calls the intellectual stages of any creative written work, namely, preparation, incubation, illumination and verification of the final result. With the employment of longer periods of preparation and incubation many writers would be prevented from arriving at erroneous conclusions. However, those who present their subjects, not too dogmatically, and who have made all available attempts at verification of their conclusions may be pardoned if later investigation and research proves them to be incorrect. Had the periods of incubation and preparation of my paper been longer I would, perforce, have had to take into consideration a case which occurred soon after the publication of the article. A patient who was studied by serial roentgenograms developed a subperiosteal hemorrhage in the femur. Clinically, the diagnosis was confirmed by the usual signs and symptoms. At no time did the roentgenograms reveal any of the changes which I had described as occurring in the prehemorrhagic stages. To have this occur within several months after publication of the paper was, to say the least, disconcerting (Fig. 1).

Caffey[2] in 1941 stated that in human scurvy the deficiency of vitamin C is rarely complete or continuous but there is more frequently a series of fluctuating remissions and relapses that produce synchronous active and healing lesions in the bones. For this reason he believes the skeletal changes cannot be satisfactorily classified into progressive stages from early onset to complete healing. This might explain the roentgen findings in the case just quoted. Sufficient vitamin had been given to obscure the usual signs of scorbutic atrophy but not sufficient to prevent the formation of a subperiosteal hemorrhage.

In 1935 Kato[4] published an excellent critique of the roentgen signs of infantile scurvy and emphasized the fact that none of these signs is pathognomonic except the subperiosteal hemorrhages. It is, of course, well known that the increased density of the zone of temporary calcification is found in congenital syphilis, in healed rickets, in poisoning by lead and other heavy metals. Zones of lessened density appearing behind

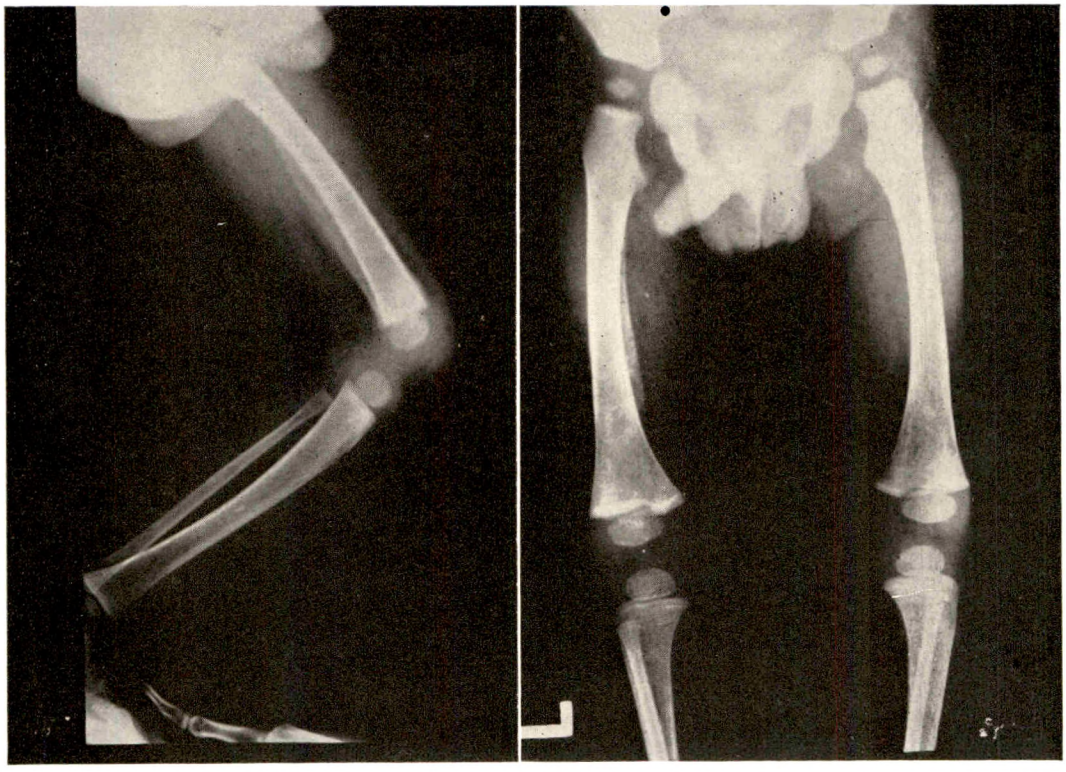


FIG. 1. Subperiosteal hemorrhage in the femur. No other roentgen signs of infantile scurvy are shown.

the zones of temporary calcification are found in congenital syphilis and in the bone changes of leukemia. The ring about the epiphyseal center can be found in cases of residual palsy following anterior poliomyelitis or bone atrophy due to other causes. Lateral spur formation can be found occasionally in rickets uncomplicated by scurvy, and epiphyseal separations occur in congenital syphilis. It cannot be too strongly emphasized that the roentgen appearance of the atrophy caused by scurvy is a composite one and that the diagnosis is based on the signs considered collectively. Other causes of bone atrophy must be eliminated by differential diagnostic methods such as the history and clinical laboratory examinations.

In 1935, Park and his associates[5] published in the Sir Thomas Barlow Birthday number of the *Archives of Diseases in Childhood* a most voluminous and exhaustive study of the early bone changes in infantile scurvy. The early roentgen signs were described and were detected in the lower ends of the diaphyses of the radius, ulna and tibia and in the upper end of the humerus. In the knee joint, the distal end of the femur only showed the lesions when the scorbutic process was well advanced. The upper end of the diaphysis of the tibia also showed changes but it was not as valuable a site for their demonstration as the distal ends of the ulna and radius. In the roentgenogram the changes were the slightest fuzziness of the cortex at the distal outer border of the diaphysis with the slightest rarefaction of the neighboring cancellous tissue. The cortex was so thin in some cases as to be altogether lacking. When the lesion was further developed, the defect became more definite. It then assumed the form of a cleft or crevice just behind the distal border of the diaphysis. In some cases this crevice was so slight that it almost escaped notice. In others it extended a short distance into the substance of the bone or half way across, or it had the appearance in

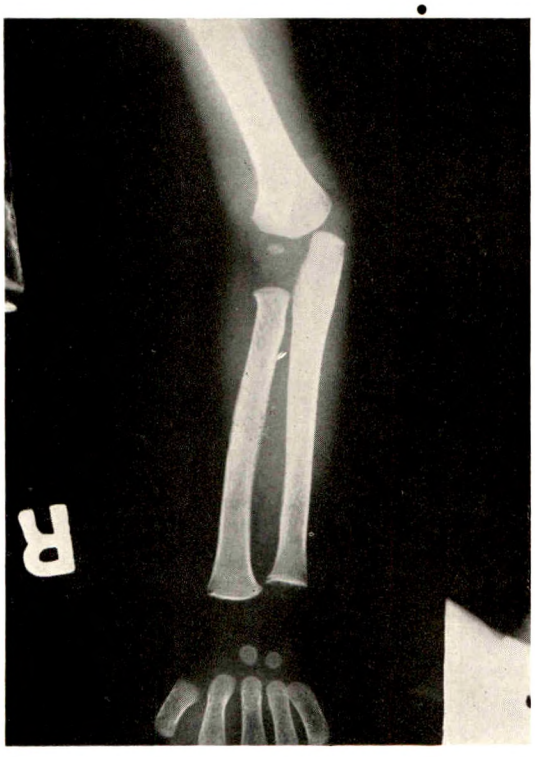


FIG. 2. Slight rarefaction and indentation at the distal border of the diaphyses of the radius and ulna illustrating the sign described by Park *et al.*, the so-called "corner sign."

some instances of having been torn away from the shaft of the bone itself. Sometimes instead of a cleft, the outer corner of the distal, lower border of the diaphysis showed a triangular area of rarefaction. In others, this corner appeared rounded and was thrust beyond the outer end of the distal extremity and was greatly rarefied. Park called this sign "bagging." Others in referring to it have termed it the "corner sign." The underlying pathological changes causing the findings in the roentgenograms are very completely described in the article by Park and his associates (Fig. 2).

In their conclusion they state that there are no early roentgen signs of scurvy. The slight roentgen changes described enable the diagnosis to be made by roentgen examination of the skeleton somewhat earlier than previously. The scorbutic deformity of the ribs is useful as a means of recognition of the disease when fully developed. The chief reliance, however, must still be on symptoms and, of these, pain and tenderness in the legs are the most important.

In their discussion of the early signs of scurvy, Park *et al.* stated that ground glass rarefaction of the shaft is not indicative of an early stage of the disease and emphasized the fact that it is not pathognomonic as it occurs in atrophy due to other causes than scurvy. The cortex does become thin and the bone does present a ground glass appearance but, they state, the bone intervening between the cortical shadows in the roentgenogram does not have a ground glass texture if it has reached an advanced stage of development. The ground glass quality is caused by an increased porosity of the cortex and the increased porosity is the result of absorption of the walls of the tunnels in the cortex.

This paper by Park and his associates necessitates a revision of the signs. The "corner sign" is one of the early if not the earliest roentgenographic sign. Shall the other signs described as occurring in the first stage be discarded as early signs? In the series reported in my paper of 1928, the ground glass appearance and thinning of the cortex and the other signs enumerated were found in 13 of the 56 cases in which a questionable clinical diagnosis had been made in 2; 5 had been diagnosed as scurvy; 4 were sent for roentgen examination with diagnoses other than scurvy, and in 2 cases no record could be found of the diagnosis made before roentgenological examination. This indicates that even if the ground glass appearance and thinning of the cortex are not early signs, they nevertheless are useful in making a diagnosis of scorbutic atrophy previous to the roentgen recognition of subperiosteal hemorrhages and even before the clinical diagnosis is possible. It may be wise, in view of Park's work, to make no attempt to divide the prehemorrhagic stage into two roentgenographic stages. However, in the analysis of the cases of the 1928 series, Pelkan's[6] contention was borne out that when the zone of rarefaction appears in the roentgenogram the disease is so far de-

veloped that clinical recognition is easy. If the "corner sign" is not always found, it may be due to the lack of sufficiently early examination.

The increased interest and the education of the laity in vitamin deficiency and more numerous Child Welfare and Health Clinics have tended to reduce the incidence of infantile scurvy. However, for numerous reasons a child may refuse his orange juice or the administration of vitamin C in other forms and the deficiency of the vitamin may be incomplete or not continuous. It may well be that the majority of patients suffering from infantile scurvy either now or in the future will conform to the type as stated by Caffey. Granted that there are or will be few cases which progress to subperiosteal hemorrhages by a continuous lack of vitamin, is it not useful to know the appearance and the progression of the lesions roentgenographically from the earliest detectable signs through the stage of subperiosteal hemorrhage to the healing stage? Is it not advantageous to know the signs of healing as it occurs before the hemorrhages appear? It should be the aim of the roentgenologist to assist in making the diagnosis before their appearance. Knowing and recognizing the progression in the cases of continuous lack of vitamin, it will be less difficult for the roentgenologist to recognize the signs of healing and remission in those cases in which the lack is not continuous.

REFERENCES

1. BROMER, R. S. Roentgen-ray diagnosis of infantile scurvy. AM. J. ROENTGENOL. & RAD. THERAPY, 1928, *19*, 112–125.
2. CAFFEY, J. In: Diagnostic Roentgenology. Ross Golden, Editor. Thomas Nelson & Sons, New York, 1941. Chap. 15, p. 1044.
3. DEMPSTER, J. H. Medical Writing. Bruce Publishing Co., St. Paul, 1937.
4. KATO, K. Critique of the roentgen signs of infantile scurvy, with report of 13 cases. *Radiology*, 1932, *18*, 1096–1110.
5. PARK, E. A., GUILD, H. G., JACKSON, D., and BOND, M. Recognition of scurvy with especial reference to early x-ray changes. *Arch. Dis. Childhood*, 1935, *10*, 265–294.
6. PELKAN, K. F. The roentgenogram in early scurvy. *Am. J. Dis. Child.*, 1925, *30*, 174–188.

CALCIFICATION OF RENAL TUMORS*

By GEORGE AUSTEN, JR., M.D.
BOSTON, MASSACHUSETTS

THERE are many factors to be considered in determining the prognosis in cases of renal cancer, but experience has proved that no factor alone is of infallible aid. For this reason, any variation in the usual pattern of renal tumors should be studied to determine whether it has a significant relationship to the prognosis of kidney tumors in general. One of the occasional variations in the pattern of these neoplasms is the occurrence of calcium in the tumor tissue. Although the literature abounds in articles dealing with calcification of the kidney in tuberculosis and other conditions of so-called metastatic calcification, comparatively little attention has been directed to the calcification of renal tumors. When reviewing our cases in an effort to analyze factors of importance in prognosis, we noted an apparently unusual number of calcified deposits in the series. Since the majority of textbooks and monographs on urology make little reference to this condition, it seems worth while to report in brief the results of an analysis of these cases.

For those interested in the physical, pathological, and physiochemical aspects of calcification reference is made to the excellent studies of Virchow,[21] Wells,[23,24] Schmidt,[20] Barr,[5,6,7] and Albright.[2,3] In brief review, however, it is known that calcification occurs in the human body as either a physiologic or a pathologic process. The former is a normal process concerned with the deposition of calcium salts in the development and formation of bone. The latter is an abnormal process in which calcium salts are deposited or precipitated in tissues or organs which do not ordinarily contain such deposits.

Although advances are being made in the study of both physiologic and pathologic calcification, the exact physiochemical changes involved in the deposition of calcium are not yet clearly understood. Apparently the initial factor in pathological calcification is a loss of local cellular activity. This is followed by degenerative and retrogressive changes such as hyalinization, necrosis, and cyst formation. Thereafter, as Wells stated in 1911,[23] "The insoluble salts are laid down in a matrix especially prepared to receive them; in bone formation the homogeneous acellular matrix of the cartilage; in calcification some acellular necrotic tissue, or more especially, homogeneous elastic fibers or hyaline degenerated connective tissue, each of these latter bearing marked structural resemblance to the hyaline matrix of cartilage or osteoid tissue." But why calcium deposits should appear in one and not the other of two otherwise histologically similar tissues is still unsolved. Undoubtedly the amount of blood supply is important; with a free circulation there is no calcification; with too little circulation necrosis is followed by slow calcification or none at all. However, as believed by Wells and others, and as stated recently by Goldstein and Abeshouse,[13] "It is generally agreed that any dead or damaged tissue, infected or uninfected, so large or so situated that it cannot be absorbed, may become infiltrated with calcium salts. . . . The degree or extent of the calcification may be modified by general changes in calcium metabolism or in the amount of calcium in the blood or tissue fluids." Where calcification occurs in renal tumors, there is little or no evidence that the concentration of serum phosphatase or serum calcium and phosphorus plays any important rôle in this abnormal calcium deposition.

The appearance of calcium deposits in renal tumors is not mentioned in the early treatises on that subject by Albarran and Imbert[1] or by Garceau.[12] In 1901, Morris[19]

* From the Urological Clinic of the Peter Bent Brigham Hospital and the Laboratory for Surgical Research, Harvard Medical School, Boston, Massachusetts.

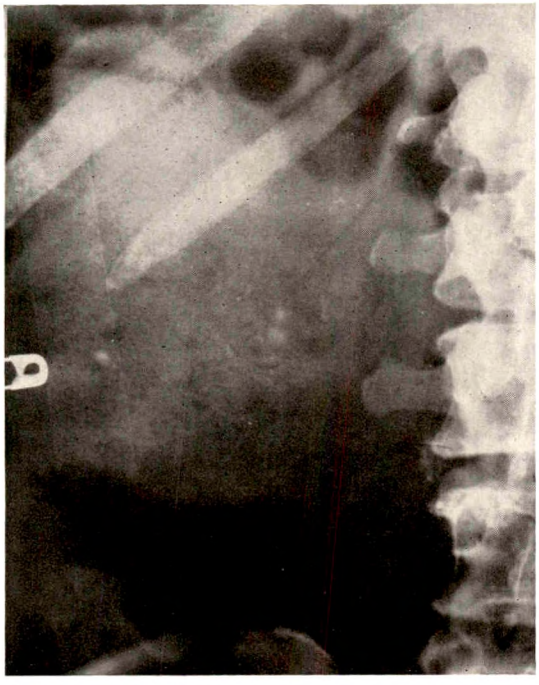


FIG. 2. Roentgenogram of large inoperable right hypernephroma in a male, aged fifty-two. Biopsy. Note diffuse calcification.

Although these cases are not included in the mortality figures, it is interesting to note that the calcium deposits demonstrated roentgenologically in this group are similar to those seen in the verified cases of renal tumor.

Of the 106 tumors verified by microscopic examination, 98 were malignant and 8 were benign. In the latter group were 6 adenomas of the renal parenchyma, 1 papilloma of the renal pelvis, and 1 leiomyoma of the renal pelvis. Only one of these, the leiomyoma, showed abnormal calcification. Of the 98 malignant neoplasms, 85 were carcinomas of the renal parenchyma, 8 were tumors of the renal pelvis, and 5 were miscellaneous tumors, including 2 embryonal or Wilms' tumors, 1 fibrosarcoma, 1 leiomyoliposarcoma and 1 lipofibrosarcoma.

Calcium deposits in the tumor tissue were demonstrated by roentgenologic and microscopic examination in 16 of the 98 malignant cases, a percentage of 16.3. Of these 16 cases, 14 were carcinomas of the renal parenchyma, 1 was a papillary carcinoma of the renal pelvis, and 1 was a leiomyoliposarcoma of the renal capsule. There were 12 males and 4 females in the group, with an average age of 53.5 years, the youngest being twenty-seven and the oldest sixty-seven years. The right kidney was the site of calcification in 5 instances, the left in 11 instances. Since many malignant tumors of the kidney cause no symptoms in the early stages of their growth, it is difficult to determine even approximately how long they have existed, although it is probable that they have been present for some time before manifesting themselves. In our group of cases with calcified tumors, the average duration of symptoms varied between five and eight months, the shortest interval between the onset of symptoms and operation being two weeks, the longest two years. In contrast, the average duration of symptoms for cases with non-calcified malignant tumors varied between ten and fourteen months.

Studies before operation revealed no evidence of distant metastasis in any of these patients. The tumor mass, palpable in 12 of the 16, was easily movable in the majority. Except for 1, who showed the systemic effects of necrosis and infection in the tumor, all were considered to be good operative risks. Nephrectomy was performed in 14 cases, while 2 were subjected only to biopsy because of the extensive local invasion of the tumor found at exploration. No deaths occurred during the immediate postoperative period.

The shadows of calcification in renal tumors, as seen in the roentgenograms, assumed various patterns and were not in themselves distinctive. In the majority of cases, however, the involved kidney was enlarged or irregular. The calcified material could be demonstrated to lie in the area of the suspected mass and could be localized even more after the injection of a radiopaque iodide solution. Some shadows showed a scattering of irregular, mottled deposits throughout the entire tumor, while others showed only several small spiculated deposits in either the central or peripheral portions. Sometimes the calcified material

described a case of alveolar carcinoma of which the renal capsule cut as if calcified in parts, but he ascribed no prognostic sigficance to this phenomenon. Quoting Robert's observation he stated that "A fibrous tumor growing on the substance of the kidney may ossify and transform a large part of the organ into a bony mass." Although all authors describe the occurrence of cartilage, and occasionally bone, in the mixed embryonal tumors of the kidney, Watson and Cunningham,[22] Kelly and Burnam,[15] and Young[25] make no reference to calcification in other types of renal neoplasms. The attention of the urologist and roentgenologist was drawn to this interesting pathological change in the more common renal cancers by Arkin[4] in 1926. He reported the first case of calcification in a hypernephroma in which an accurate diagnosis was made by roentgenographic study and confirmed by operation. Since that time, other reports of this phenomenon have appeared with greater frequency in the literature. These have been recently summarized by Goldstein and Abeshouse.[13] However, in spite of the increasing frequency of these reports in the literature, the recent textbooks of urology fail to review in detail this feature of kidney tumors. In discussing papillary carcinoma with clear cells, Ewing[11] states: "The gross structure is divided into many small cysts containing clear or brownish or bloody or gelatinous material. Areas of necrosis and hemorrhage may be frequent, and these may fuse, yielding large cystic cavities. There may be considerable calcific deposits." Hinman[14] reproduces a roentgenogram showing calcium deposition in a tumor, and says: "Occasionally renal tumors become diffusely calcified and may give a characteristic X-ray picture." MacKenzie,[18] in discussing the various types of benign adenomas in Cabot's "Modern Urology," states that cystic changes may occur in these tumors and adds that "Calcareous changes are also relatively common." Under the subject of hypernephroma, Keyes and Ferguson[16] say: "The tumor usually remains quiescent from 45 to 60 years. It may then grow so slowly that a marked

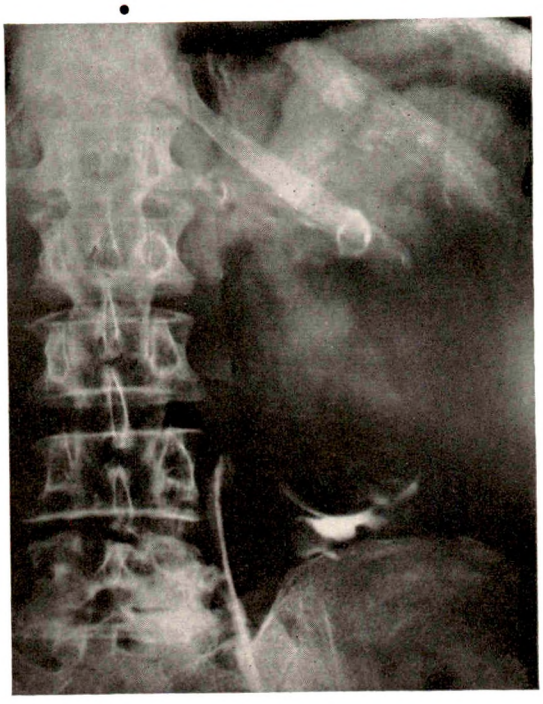


FIG. 1. Roentgenogram of encapsulated hypernephroma with calcification in a female, aged sixty-two. Left nephrectomy.

desmoplastic reaction is set up in the kidney about it, and this process may go on to complete calcification in the capsule of the tumor. We have seen such a tumor, the capsule of which was so hard as to require the use of a skull saw for its division." Eisendrath and Rolnick[10] state: "One can see calcified areas in a hypernephroid tumor but so seldom does this occur that plain radiography in general may be said to be of little assistance in making a diagnosis." In the latest textbook of urology by Lowsley and Kirwin[17] no reference is made to this subject.

From April, 1913, to May, 1941, 131 tumors of the kidney were recorded in the files of the Peter Bent Brigham Hospital, 25 of which were not verified by pathological examination. In this group of 25 there were 3 which showed roentgenographic evidence of calcium shadows in the tumor. In each the symptoms were of at least two years' duration, a mass was palpable in the flank, and death occurred as a result of the disease four to twelve months after examination.

was arranged in radial or circular strands, occasionally in whorls. One case had strands of calcium deposited in a laminated pattern and confined to a quadrant of the apparent capsule of the tumor. When deposited in clusters, the shadows were of quite irregular consistency. In two instances the calcium deposits closely resembled those seen in renal tuberculosis and were diagnosed as such when roentgenograms showed old tuberculous lesions in the lungs. However, further study of the retrograde pyelograms showed no cavitation or ulceration of the calyces, and the clusters of calcium could be seen extending into the tumor area. Similarly, the calcified areas in the papillary carcinoma of the pelvis were at first mistaken for pelvic calculi, but on closer examination after pyelography, they appeared more irregular in shape and consistency than the usual calculi and were apparently scattered in strands throughout a mass which almost filled the pelvis. Braasch and Griffin[8] have pointed out that one must distinguish carefully between the calcified shadows in renal tumors and those caused by lithiasis and tuberculosis. They state that "the absence of any clinical, cystoscopic, or urographic data suggestive of either lithiasis or tuberculosis usually would exclude these conditions."

A rigid pathological classification of carcinomas of the kidney parenchyma is impossible because of the varied cellular picture found in different portions of the same tumor. This fact would seem to substantiate the theory that the majority of these tumors are of renal origin. We have therefore attempted to group our 14 calcified cases according to the predominant type of structure present. Thus, there were 9 carcinomas of the so-called "hypernephroma" type, 2 papillary adenocarcinomas, 1 tubular or alveolar carcinoma, and 2 small cell carcinomas. Pathological sections of these tumors, as well as of those of the pelvis and capsule, showed multiple areas of hemorrhage, necrosis, and cystic degeneration. The degenerative changes varied in degree, some being grossly visible on section, while others were microscopic in size. There were



FIG. 3. Roentgenogram of rapidly growing small cell carcinoma of right kidney in a male, aged twenty-seven. Right nephrectomy. Note diffuse calcification in tumor at upper pole.

both recent and old areas of hemorrhage. Many sections showed replacement of these areas by fibrous tissue proliferation, collagen deposition, and hyalinization. Calcium was always deposited in or about these areas, in some instances apparently precipitated directly in the center of a mass of necrotic cells, but more often deposited in the interstices of the hyalinized fibrous tissue. Deposits were also found surrounding small vessels adjacent to regions of necrosis and hemorrhage. These vessels were supported by an extremely delicate stroma, in which were cords of partially degenerated tumor cells, and they frequently showed a marked proliferation of their endothelial lining and almost complete obliteration of their lumina. In one case cholesterol crystals were found in a small area of necrosis, while in another there was an abortive attempt at cartilage formation. In a third instance true bone formation was seen about the periphery of a large mass of necrotic material. Except in 2 cases where a

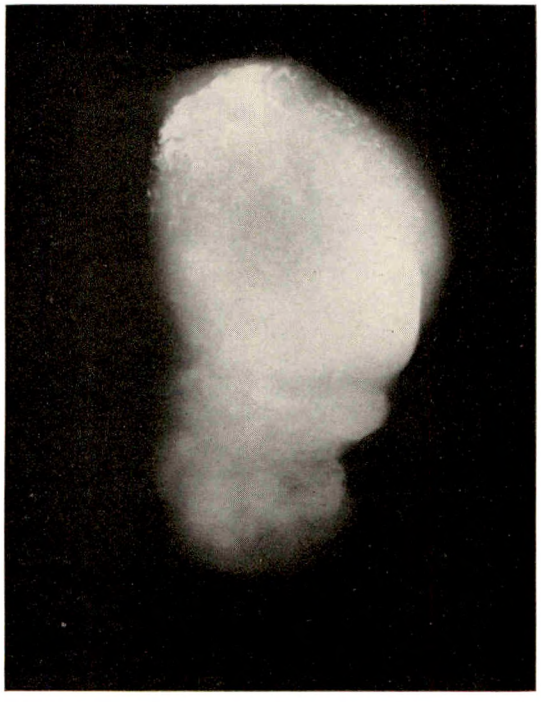


Fig. 4. Roentgenogram of specimen of small cell carcinoma with calcification shown in Figure 3.

coexisting acute and chronic pyelonephritis existed, there was little or no inflammatory reaction in the tumor tissue adjacent to regions of necrosis and calcification.

Follow-up data were available on 13 of the 16 cases. Of this group, 2 patients, 1 with hypernephroma and 1 with a papillary carcinoma of the pelvis, are living and well one and one-half and five years respectively after nephrectomy. Two patients, both of whom had clear cell carcinomas of the hypernephroma type, are alive one and two years after nephrectomy, but both have multiple metastases. Seven patients died of metastases within four to forty-eight months after operation. Five of these were subjected to nephrectomy, while 2 had merely an exploratory operation and biopsy. Two patients died of the complications of cardiovascular disease two and two and one-half years after nephrectomy but in neither instance was there any evidence of recurrent or metastatic tumor. Of the 3 patients whose status is at present unknown (all of whom had tumors of the hypernephroma type) 1 was alive and well approximately one year after nephrectomy, while 2 were alive but had metastases within one and one-half years after operation. Thus, if we include only the 13 cases of which we have follow-up data, the survival rate is 15.3 per cent. If we include the remaining 3 cases and assume that 1 is alive and 2 are dead, the survival rate rises to 18.7 per cent. In contrast, the survival rate for the 82 cases of tumors without calcification averages between 28 and 33 per cent.

COMMENT

The occurrence of calcification in 16.3 per cent of our malignant renal neoplasms would seem somewhat unusual were it not for the fact that others (Braasch and Griffin,[8] and Cahill and Melicow[9]) also report an incidence almost as high. Although calcification does occur in tumors of other organs of the body, notably in some tumors of the brain and in benign uterine leiomyomata, the calcified deposits in these instances are generally considered to be indicative of the slow growth and relatively benign character of the lesions. Benign tumors of the kidney, however, are comparatively rare, and in our series only 1 (12.5 per cent) of 8 benign lesions showed calcification. Comparing this figure with that of the malignant tumors, it is evident

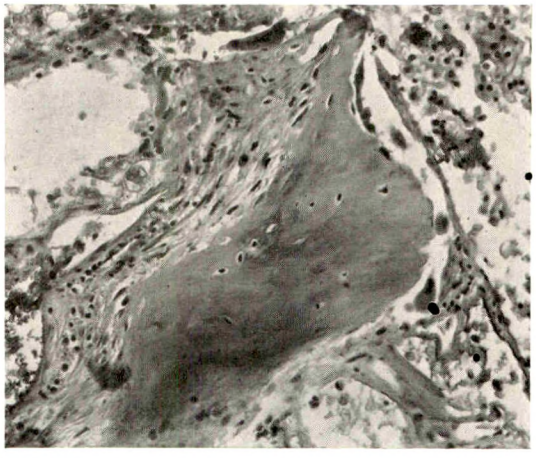


Fig. 5. Photomicrograph of hypernephroma removed from a male, aged fifty-six. This is the only case in which true bone formation was seen. Eosin and methylene blue stain. ×300.

that the appearance of calcification in the roentgenograms is no indication of the benign or malignant character of the tumor.

As stated previously, experimental and clinical observation has shown that the pathological deposition of lime salts is dependent upon loss of cellular activity, hemorrhage, necrosis, and hyalinization. Since malignant tumors of the kidney are particularly prone to these degenerative changes, they might be expected to show pathological calcification rather frequently. Although the rate of calcification is extremely variable and not proportionate to the degree of hemorrhage, it is of interest to note that in the cases having calcified tumors the duration of symptoms from the onset to the time of treatment was definitely less than in those which had non-calcified tumors. On the other hand, the *amount* of calcium deposited in a given area is entirely independent of the extent of degeneration and appears to be governed by some factor or factors as yet undetermined. This feature of pathological calcification is well exemplified in the present series where as much or more calcium was found in tumors with minimal areas of necrosis as in those with larger areas. Moreover, there seemed to be no direct relation between the degree of hemorrhage or necrosis and the grade of malignancy as judged by the usual gross and microscopic criteria. Many of the non-calcified neoplasms which were considered comparatively benign by microscopic examination showed equally as much hemorrhage and necrosis as others which were considered extremely malignant. Likewise, the size of the tumor appeared to have no direct bearing upon the extent of degeneration, the amount of calcification, or the degree of cellular activity, although in general the larger neoplasms showed more extensive necrosis than the smaller ones.

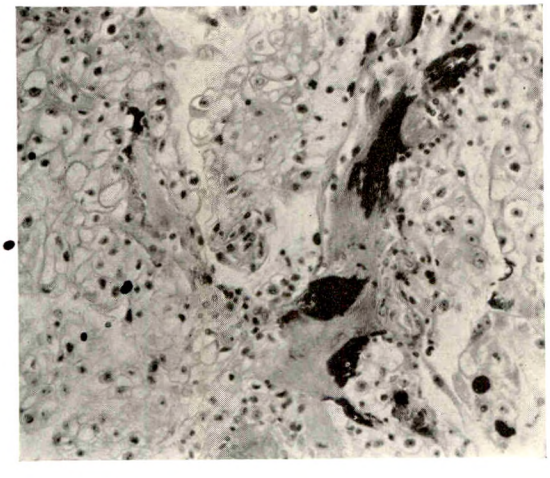


Fig. 6. Photomicrograph of hypernephroma removed from a male, aged sixty-two. Calcium deposited in strands.

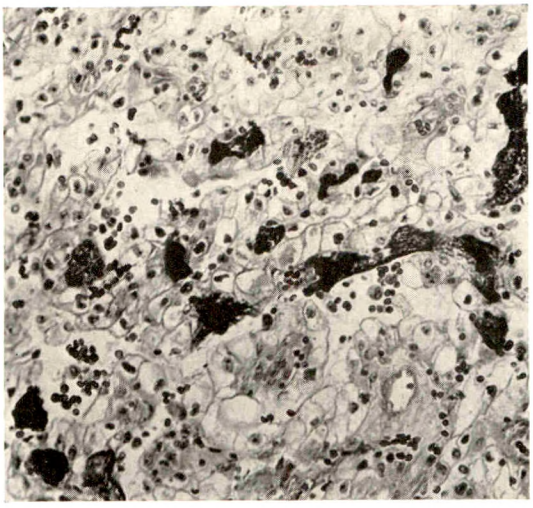


Fig. 7. Photomicrograph. Same case as Figure 6, showing more scattered deposits of calcium than in the previous figure.

While no accurate deductions as to the specific cause and significance of the calcification occurring in malignant renal tumors can be derived from these observations, the occurrence of this phenomenon may be of some prognostic importance. Braasch and Griffin[8] noted roentgenographic evidence of calcification in 7 cases and stated that 4 of these were alive at the end of five years. They feel that calcium deposition in renal tumors is a favorable sign. Goldstein and Abeshouse[13] hold a similar opinion. Cahill and Melicow,[9] on the other hand, consider the prognosis of tumors with calcification to be less encouraging than those without calcification. They reported 12 verified and 2 unverified cases of renal tumors with calcification, only 1 of whom

was alive without demonstrable metastases two years after operation. Our figures tend to substantiate their experience. In our series the survival rate of those with calcification is 15.3 per cent, while of those without calcification it is approximately 30 per cent. However, because of the statistical standard of error inherent in figures based on such a small number of cases, it must be said that this analysis precluded the possibility of drawing positive conclusions until further observations on this subject are reported by others.

SUMMARY

1. A review of 98 verified malignant tumors of the kidney has been made. Of this group, 16 tumors showed calcium deposits by both roentgenographic and pathologic examination.

2. The significance of this phenomenon has been discussed.

3. While the survival rate of those cases without calcification is approximately 30 per cent, for those with calcification it is 15.3 per cent.

4. Although no positive conclusions as to the prognostic importance of this condition can be derived from the study of such a small series, it appears that the prognosis of those cases with calcification is less favorable than of those without calcification.

REFERENCES

1. Albarran, J., and Imbert, L. Les tumeurs du rein. Masson et Cie, Paris, 1905, pp. 501–511.
2. Albright, F., Baird, P. C., Cope, O., and Bloomberg, E. Studies on physiology of parathyroid glands; renal complications of hyperparathyroidism. *Am. J. M. Sc.*, 1934, *187*, 49–65.
3. Albright, F., and Bloomberg, E. Hyperparathyroidism and renal disease, with note as to formation of calcium casts in this disease. *J. Urol.*, 1935, *34*, 1–7.
4. Arkin, A. Calcified hypernephroma of the kidney. *Surg., Gynec. & Obst.*, 1926, *43*, 155–168.
5. Barr, D. P., Bulger, H. A., and Dixon, H. H. Hyperparathyroidism. *J. Am. M. Ass.*, 1929, *92*, 951–952.
6. Barr, D. P., and Bulger, H. A. Clinical syndrome of hyperparathyroidism. *Am. J. M. Sc.*, 1930, *179*, 449–476.
7. Barr, D. P., and Charles, C. M. Relat diseases of bone to arterial calcificatio urolithiasis. *Libman Anniv. Vols.*, 19 155–179.
8. Braasch, W. F., and Griffin, M. Prog renal carcinoma and clinical and path data affecting it. *J. Am. M. Ass.*, 1936 1343–1346.
9. Cahill, G. F., and Melicow, M. M. Cal tion of renal tumors and its relation to nosis. *J. Urol.*, 1938, *39*, 276–286.
10. Eisendrath, D., and Rolnick, H. C. Ur Fourth edition. J. B. Lippincott Co., delphia, 1938.
11. Ewing, James. Neoplastic Diseases. Thir tion. W. B. Saunders Co., Philadelphia,
12. Garceau, Edgar. Renal, Ureteral, Periren Adrenal Tumors and Actinomycosis Echinococcus of the Kidney. D. Appleto Co., New York, 1909.
13. Goldstein, A. E., and Abeshouse, B. S. fication and ossification of kidney; revi literature and report of cases. *Radiology*, *30*, 544–578; 667–685.
14. Hinman, F. The Principles and Practi Urology. W. B. Saunders Co., Philade 1936, p. 1032.
15. Kelly, H. A., and Burnam, C. F. Disea the Kidney, Ureter and Bladder. Secon tion. D. Appleton and Co., New York,
16. Keyes, E. L., and Ferguson, R. S. Ur Sixth edition. D. Appleton-Century Co., York, 1936, p. 361.
17. Lowsley, O. S., and Kirwin, T. J. Cl Urology. Williams and Wilkins Co., Balti 1940.
18. MacKenzie, D. W. In: Modern Urology. Cabot. Third edition. Lea and Febiger, delphia, 1936, p. 692.
19. Morris, Henry. Surgical Diseases of K and Ureter. Cassell and Co., London, pp. 557–626.
20. Schmidt, M. B. Ueber die Verkalkung Nierenepithelien bei Sublimatvergiftung bei Dysenterre. *Centralbl. f. allg. Path. u. Anat.*, 1920, *30*, 497–500.
21. Virchow, R. L. Kalk-Metastasen. *Virc Arch. f. Path.*, 1855, *8*, 103.
22. Watson, F. S., and Cunningham, J. H. Dis and Surgery of Genito-Urinary Tract. Le Febiger, Philadelphia, 1908, p. 239.
23. Wells, H. G. Calcification and Ossification Harvey Lectures. 1910–1911, pp. 102–1
24. Wells, H. G. Chemical Pathology. Fift tion. W. B. Saunders Co., Philadelphia, pp. 486–504.
25. Young, H. H. Practice of Urology. Thir tion. W. B. Saunders Co., Philadelphia, p. 520.

VOL. 49, NO. 5

ROENTGENOLOGIC EXAMINATION OF THE PHARYNX

By SIEGFRIED W. WESTING, M.D.
*Roentgenologist, Brooklyn Cancer Institute**
BROOKLYN, NEW YORK

IN THE majority of cases a complete examination of the three portions of the pharynx, namely, the nasopharynx, the oropharynx, and the laryngo- or hypopharynx, can be made by the rhinolaryngologist without the help of roentgen procedures. Yet there are numerous instances where a roentgenologic examination may be of material assistance. When the nasopharynx is the seat of a malignant new growth the roentgenologist may have to determine whether or not extension into the adjacent bones (the base of the skull) is present. The oropharynx, although easily accessible to inspection and palpation, may be subjected to roentgen examination to great advantage, particularly in order to visualize the valleculae, the two important recesses in front of the base of the epiglottis. Regarding the hypopharynx the roentgen examination is able to add a good deal of confirmatory and contributory information to the rhinolaryngologic study. Here again the leading rôle is played by two recesses: the piriform sinuses which hang down from the two lateral aspects of the anterior surface of the hypopharynx and are adjacent to the sides of the larynx. If a hypopharyngeal lesion is so large that the rhinolaryngological instruments cannot pass it, the only means to determine its lower end is the roentgen study (see Cases III and V). This study at the same time reveals the condition of the neighboring organs, for instance, the retropharyngeal tissues. Thus information is obtained roentgenologically which cannot be acquired otherwise.

The reader who wishes to familiarize himself with the roentgen study of the pharynx is referred to a number of recent publications.[5,6,8] Here he finds instructions about the roentgenoscopy, roentgenography and planigraphy (body section roentgenography) of the structure and function of the pharynx in times of health and disease. In spite of the wealth of information thus available, the pharynx does not universally receive from the roentgenologist the amount of attention which appears warranted.

Such neglect would be of less consequence if the contacts of the roentgenologist with the pharynx were confined to cases referred to him by the rhinolaryngologist. Actually these contacts are much more numerous. Whenever the roentgenologist is performing an opaque meal examination of the alimentary tract, he has an opportunity to examine the lower half of the pharynx and it is this opportunity that is neglected quite frequently as illustrated by the fact that most reports about a so-called gastrointestinal series and most books on roentgen examination of the alimentary tract[2,3,7] start with a description of the esophagus instead of the lower pharynx which is really the first segment passed by the meal after it leaves the mouth. Two reasons seem to explain this subordinate position of the pharynx.

First, the roentgenologist who sets out to examine the alimentary tract may take it for granted that in the absence of the suggestive symptom of difficulty in swallowing, the pharynx can be ruled out as the seat of affection. That this assumption is fallacious is exemplified by our Case III, where advanced pathological changes are present without characteristic symptoms. It is obvious that under such circumstances the roentgenologist may create a situation quite embarrassing to himself if he should happen to overlook and fail to report important pathological changes which with correct technique and careful interpretation could have been revealed.

The second reason for the lack of attention directed toward the pharynx is the

* Department of Hospitals, City of New York.

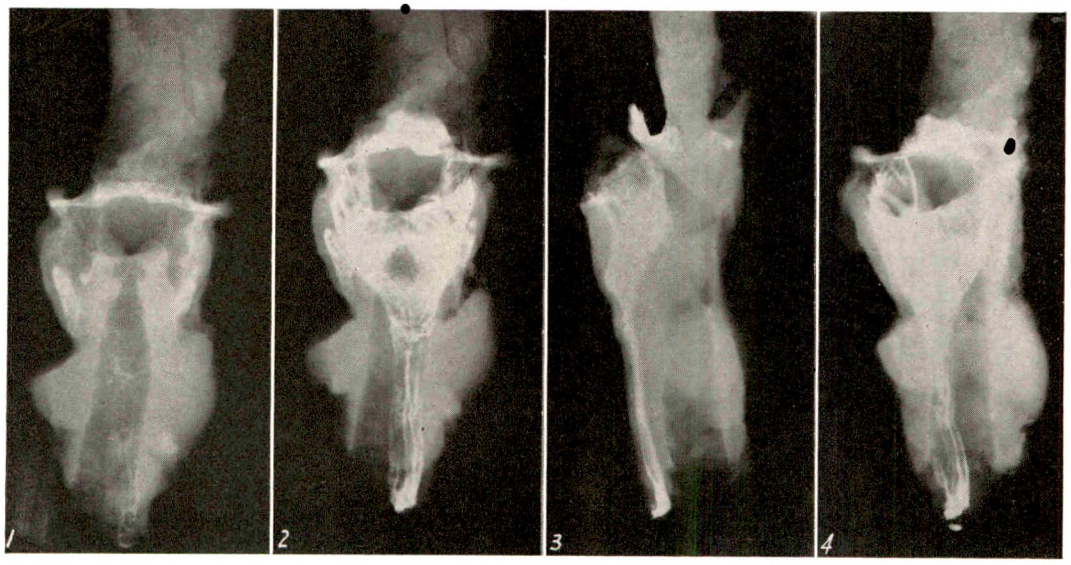


FIG. 1. Posteroanterior view of a specimen of a normal tongue, larynx, lower half of pharynx and proximal end of trachea and of esophagus after fixation in formalin. Slightly stained with barium water mixture. Note the valleculae (somewhat flattened out as compared to condition during life); piriform sinuses, just inside of the lime containing laminae of the thyroid cartilage; air space of larynx and upper trachea, vocal cords in paralysis position, and mucosal pattern of upper esophagus. Visualization of this pattern is very rare, as during life food is evacuated from this segment exceedingly rapidly.

FIG. 2. Posteroanterior view of the same specimen more completely filled. This picture illustrates the roentgenoscopic appearance of the barium stream in this area. During life in many instances the upper portion of the shadow solidly fills the space between the piriform sinuses. In other instances, as in our illustration, there is a defect in the middle part due to the backward bulge of the larynx. As the larynx rises during the act of swallowing the square shaped, non-filled area beneath the valleculae, visible in this illustration, does not exist during deglutition. The constriction of the uppermost centimeter of the esophagus is not evident in the specimen.

FIG. 3. Lateral view of the same specimen, almost completely filled. The valleculae are superimposed on one another. The piriform sinuses are superimposed on one another and very often on the main portion of the hypopharynx so that they are not visible as separate structures. However, turn to Figure 6 where the superimposed piriform sinuses are seen just in front of the main portion of the hypopharynx. It should be remembered that during rest the anterior esophageal wall is adjacent to the posterior wall. This fact accounts for the thread-like appearance of the non-expanded normal esophagus in the lateral view.

FIG. 4. Oblique view of the same specimen.

short duration of the filling of the normal pharynx. It takes the food no longer than one-eighth of a second to travel from the back of the tongue through the oro- and hypopharynx and cervical portion of the esophagus to the level of the clavicles.[1] From there on the descent is much slower. Changing the patient's position from upright to horizontal slows up the speed below the clavicles but has no effect above the clavicles. Even turning the subject on his head fails to retard the food in the uppermost segment of the alimentary tract.[4,9] Therefore on almost all roentgenograms, provided they reach up high enough in the neck region, this upper segment is found either empty or filled by small streaks of barium. This being the case, the rôle of roentgenoscopy becomes more important. The roentgenoscopist is likewise handicapped by the exceedingly transitory character of the filling of the pharynx and cervical esophagus. It is not possible to note accurately a visual impression in one-eighth of a second, if immediately afterwards the entire attention is to be concentrated on the important phenomena noticeable farther down as the first bolus

passes through the esophagus and cardia into the stomach.

In order to make an adequate examination of the pharynx and cervical esophagus, one ought to make it a rule to return to this region after he has finished the study of the stomach as it gradually expands under the influence of increasing amounts of opaque mixture. It is really not before then that the roentgenologist is free to study the pharynx and cervical esophagus leisurely and without the fear that he may obscure important stomach findings by administering the number of swallows necessary for the study of the upper pole of the alimentary tract. In detail, the roentgenoscopist proceeds in the following manner. After the shutter has been adjusted to oblong shape and fitted exactly over the area of the lower pharynx and cervical esophagus, the patient is asked to fill his mouth with contrast meal. His head is turned straight forward. The chin is raised half way. Less elevation of the chin would let the chin cover the pharynx, more elevation would project the base of the skull into the field of examination. When the examiner has brought his eyes to the level of the pharynx the patient is ordered to swallow.

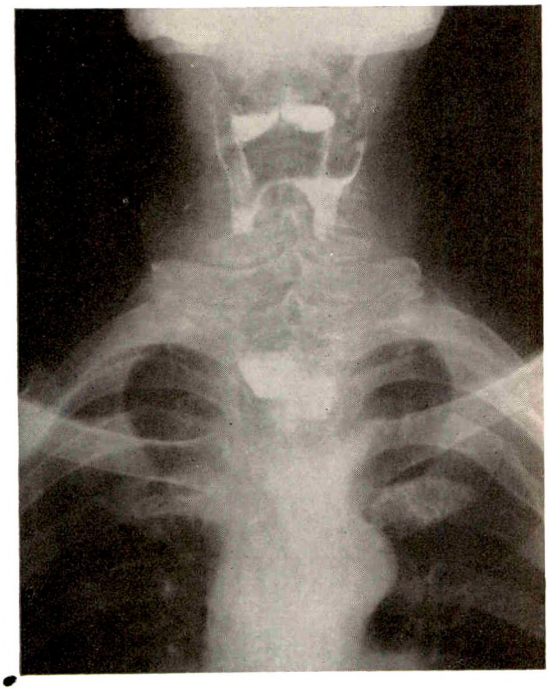


FIG. 5. Case 1. Posteroanterior view. Constricting carcinoma of the esophagus just above clavicles proved by histopathological study of biopsy specimen. The valleculae and piriform sinuses are clearly visible; they are structurally normal, proved by laryngoscopy and esophagoscopy. They are hypotonic and retain the food unduly long. Therefore a good opportunity to procure the picture of a structurally normal pharynx is afforded.



FIG. 6. Lateral view of the same case. Good demonstration of the air filled oro- and hypopharynx with barium in the bases of valleculae and piriform sinuses. One side is superimposed upon the other. The trace of barium in the collapsed hypopharynx behind the barium filled bases of the piriform sinuses records the relation of these structures. A little farther down the esophagus is dilated due to the constricting carcinoma just above the clavicles.

In normal cases the posteroanterior projection of the barium stream can be described as follows: In the beginning its width is determined by the distance of the lateral walls of the piriform sinuses. Right below this segment the esophagus starts.

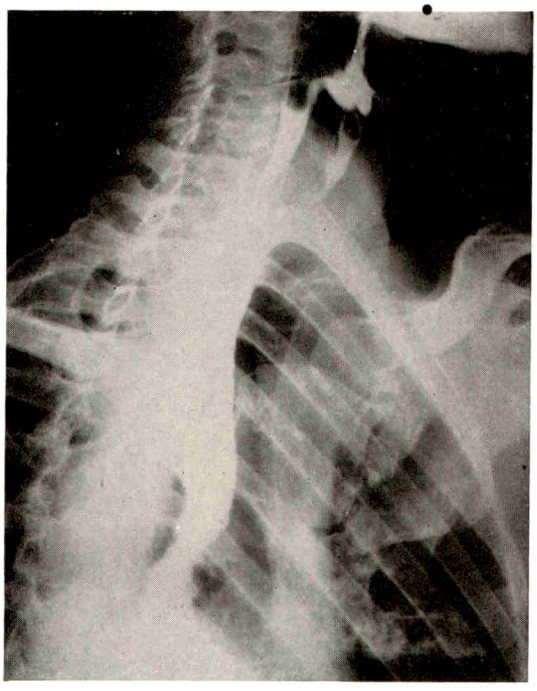


FIG. 7. Case II. Oblique view. Valleculae and piriform sinuses stand out distinctly. Extensive malignant neoplasm within lower half of esophagus leading to partial obstruction and moderate widening of the esophagus above the obstruction. The diagnosis is based on the roentgenological and clinical evidence. No esophagoscopy could be done. Since I have not found an oblique view of the barium filled pharynx in the American literature, I deemed it advisable to include this case in spite of lack of laryngoscopic and histological proof.

The lumen of its first centimeter is concentrically narrowed to about three-fourths the width of the balance of the esophagus; from then on down the ordinary width of the esophagus is noted. The wide portion of the barium stream may be thinned out or absent in and next to the midline due to the backward bulge of the larynx. Figure 2 conveys a fairly good idea of the barium as seen during the act of swallowing. The chief characteristic of this view is the completely symmetrical appearance of the barium stream. This feature renders the posteroanterior projection especially valuable because of the possibility of comparing one side with the other. Even slight asymmetries may be of diagnostic significance. As soon as the bulk of the barium has left the pharynx, the region is scrutinized for residues. These residues in normal cases are small and of short duration. They are located in the valleculae and piriform sinuses.

Due to the small amount of barium re-

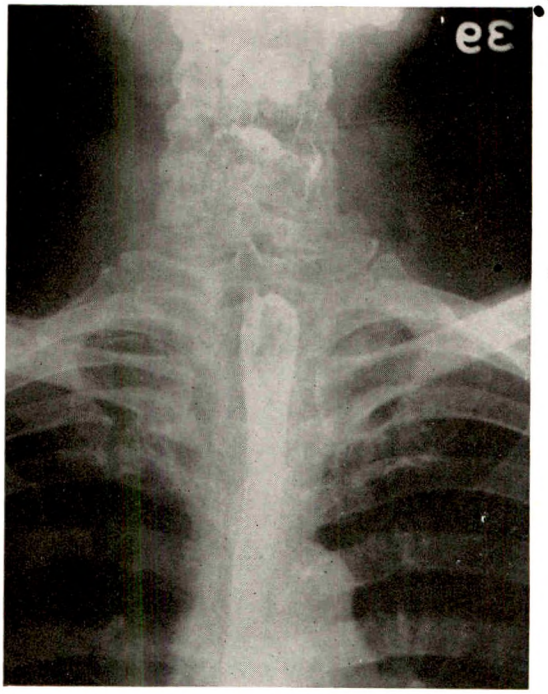


FIG. 8. Case III. Posteroanterior view. Filling of right vallecula and right piriform sinus very deficient and very irregularly outlined. Conclusion—advanced malignant new growth of right half of base of oropharynx and of right half of hypopharynx. Six days later, on October 5, 1939, laryngoscopy revealed the following: In the glosso-epiglottic fold there is a red friable mass which has a granular appearance. Biopsy was done which proved on histopathological examination to be squamous cell carcinoma. This case had been transferred to the Brooklyn Cancer Institute from another hospital on September 21, 1939, on account of a nontender swelling, size of a tangerine, posterior to the right sternocleidomastoid muscle. Biopsy of the mass had shown metastatic squamous cell carcinoma. Primary carcinoma was not known at time of transfer. The patient did not have any difficulty in swallowing. This case proves that the roentgen examination may precede the laryngoscopy and often is able to anticipate the laryngoscopic findings; sometimes it even can amplify the laryngoscopic findings inasmuch as it shows how far down a lesion extends. In our case the affection of the right piriform sinus so clearly revealed by the roentgen examination is not mentioned in the laryngoscopic report.

tained, roentgenograms of the pharynx, as a rule, are quite unimpressive. Therefore in preparing a set of normal roentgenograms for reference purposes, I found it practical to make use of the fact that in case of stricture lower down in the esophagus the amount and duration of these residues are greatly increased and the resulting appearances are much more demonstrative. We are dealing with "exaggerated normals," just as in excretion urography a compression band over the sacral region prevents the contrast fluid from draining too rapidly out of the renal calyces and pelves and thus produces "exaggerated normals." If one keeps in mind that the actual normals are of smaller size and shorter duration, the "exaggerated normals" may very well serve as paradigms of the actual normals. Although these pictures are quite characteristic, it may happen that the bizarre and torn appearance of the barium column in the upper segment of the alimentary tract confuses the less initiated interpreter and prompts him to suspect pathological filling defects. Experience proves that in cases similar to those illustrated by Figures 5, 6 and 7 a lesion in the hypopharynx and cervical esophagus has been assumed erroneously in addition to the true lesion farther down.

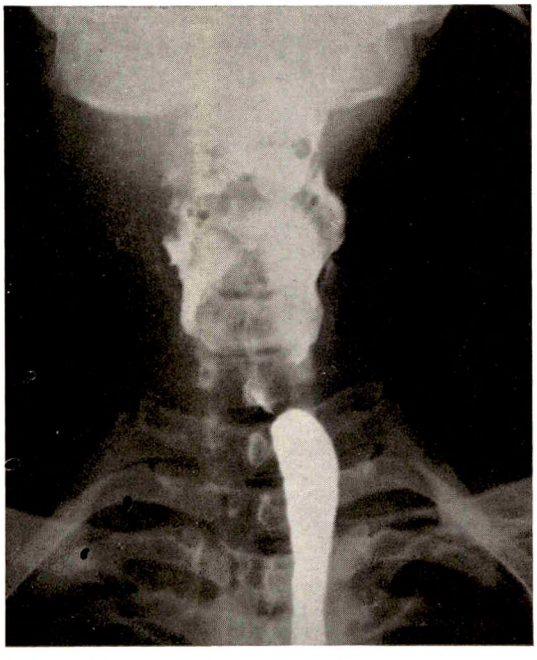


FIG. 9. Case IV. Posteroanterior view of a very advanced lesion. Laryngoscopically friable mass in right piriform sinus. Histopathologically squamous cell carcinoma.

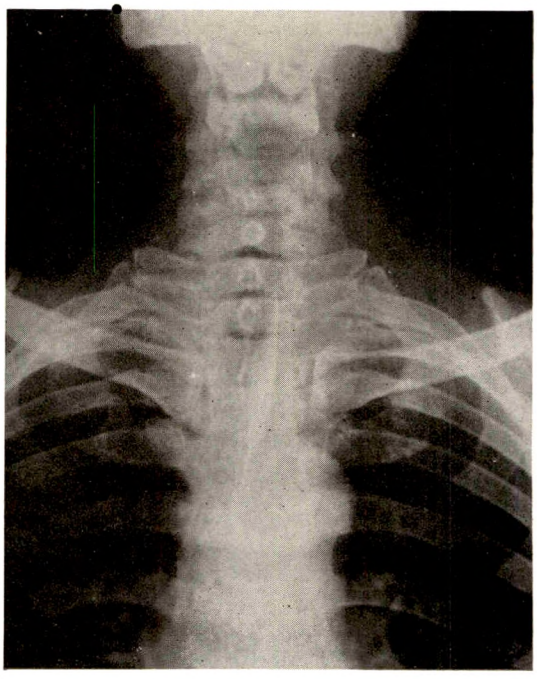


FIG. 10. Case V. Posteroanterior view. Filling defects of both piriform sinuses. The calcification in the laminae of the thyroid cartilage should not be mistaken for barium in the piriform sinuses. Lateral view of the neck demonstrated tumor formation in the arytenoid region. The conclusion drawn from the roentgen examination was: large tumor in arytenoid region and piriform sinuses. Laryngoscopically—large mass in arytenoid region which obscures the posterior extremity of the vocal cords. Histopathological examination of biopsy specimen discloses squamous cell carcinoma. Again the two examinations supplement one another most satisfactorily. Roentgenologic examination determines the downward extent of the lesion better than the laryngoscopy. The fact that the lesion affects both piriform sinuses symmetrically renders the interpretation more difficult. Carcinoma frequently affects larynx and hypopharynx simultaneously. Keeping the possibility of such an association in mind, the roentgenologist should always feel prompted to scrutinize both organs even when the examination of one only is requested.

After roentgenoscopy in the posteroanterior projection has been completed, the patient is turned and the lateral and

oblique views are studied at rest and during phonation and swallowing, the latter without and with opaque mixture. The approximate appearance of the barium column in these views is illustrated by Figures 3 and 4.

Finally, according to the roentgenoscopic findings, the number and kind of roentgenographic views are decided upon. Ordinarily the posteroanterior and the lateral views are indispensable. Since larynx and hypopharynx are frequently involved jointly in the same pathological process, both organs have to be considered by the roentgenologist, even when the examination of one only is requested (see Case v).

SUMMARY

1. The place of roentgenology in the examination of the pharynx is stated briefly.

2. Attention is called to the fact that during each opaque meal study of the alimentary tract the roentgenologist has an opportunity to examine the lower half of the pharynx; an opportunity which is often neglected for reasons presented.

3. For the lower half of the pharynx and the cervical esophagus a roentgenoscopic technique is outlined which obviates the difficulties ordinarily arising during the opaque meal study of the alimentary tract.

4. Roentgenograms of the normal pharynx are described and reproduced in posteroanterior, lateral, and oblique projections. These roentgenograms were obtained from an autopsy specimen and from patients who, because of remote affection, are better suited to furnish us with pictures of the structurally normal pharynx than healthy subjects.

5. Cases of cancer are described—one very advanced case, one with definite, but less conspicuous findings, and one with absence of the customary characteristic history of dysphagia. As cancer frequently affects larynx and hypopharynx simultaneously, the roentgenologist should scrutinize both organs, even when the examination of one only is requested.

REFERENCES

1. BARCLAY, A. E. Practical importance of mechanics in digestion. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *40*, 325–334.
2. BUCKSTEIN, J. Clinical Roentgenology of the Alimentary Tract. W. B. Saunders Company, Philadelphia, 1940.
3. CARMAN, R. D. The Roentgen Diagnosis of Diseases of the Alimentary Canal. W. B. Saunders, Philadelphia, 1920.
4. PALUGYAY, J. Untersuchungen über den Schluckakt bei Kopfstand. *Klin. Wchnschr.*, 1923, *2*, 1720.
5. PENDERGRASS, E. P., and YOUNG, B. R. Roentgen diagnosis of neoplasms of air and food passages, with particular reference to the larynx. *Radiology*, 1941, *36*, 197–211.
6. PFAHLER, G. E. Roentgen diagnosis and treatment of carcinoma of larynx and pharynx. *Radiology*, 1939, *33*, 42–53.
7. ROSENTHAL, E. Diseases of the Digestive System. C. V. Mosby Company, St. Louis, 1940.
8. YOUNG, B. R. The Soft Tissues of the Air and Food Passages of the Neck. In: Diagnostic Roentgenology. Ross Golden, Editor. Thomas Nelson & Sons, New York, 1941.
9. THOMAS, A. R. Note on the mechanism of deglutition. *Brit. J. Radiol.*, 1942, *15*, 209–210.

VOL. 49, NO. 5

POST-TRAUMATIC NECROSIS OF BONE*

By RAYMOND W. LEWIS, M.D.
Roentgenologist, Hospital for Special Surgery
NEW YORK, NEW YORK

IN RECENT years the increasing frequency of writings and discussions of aseptic bone necrosis is indicative of the importance of the subject, and of the ever widening interest in it. In this country the work and contributions of Phemister are outstanding in this field. A recent article of his, appearing in a surgical publication, is particularly comprehensive and instructive.[1] With the purpose of bringing to the attention of roentgenologists this highly significant work, and perhaps adding a few examples of the condition and discussing them from the roentgenological point of view, this paper was prepared. Omitted from the present discussion are the familiar types of aseptic necrosis occurring in growing centers of bone—the femoral head, tibial tubercle, tarsal scaphoid, metatarsal heads, vertebral bodies—known under the names of the various early writers on these conditions. Also omitted are the widely recognized lunate osteomalacia and osteochondritis dissecans, both of which probably should be classified in the post-traumatic bone necrosis group.

In the article referred to, Phemister writes in detail of the pathological processes following aseptic interruption of circulation in bone. From the surrounding living bone and joint structures there is fibrous invasion, and metaplasia and replacement of the dead bone by new bone. Phemister refers to this process as "creeping substitution" or "creeping replacement." The fibrous invasion and the metaplasia often go hand in hand; but in some cases the fibrous invasion may be far in advance of the zone of transformation, leaving a thick zone of dead bone filled with fibrous marrow. There is considerable variation in the rate of progress of this transformation, it being influenced by such factors as age, size and location of the necrotic area, function, trauma and non-union of fractures which may be present. Recent work by Phemister and coworkers showed that the reparative impulse may not last as long as dead bone persists, but that in the case of adults large necrotic areas may be incompletely removed. He also calls attention to the fact that, especially in adults, interruption of circulation in the bone of an epiphysis causes serious interference with the nutrition of the articular cartilage. He states that function hastens to some extent the rate and the extent of the repair, but he cautions that function should be limited well within the strength of the necrotic bone and of the newly forming bone during the major part of the period of creeping substitution. Otherwise fractures and more or less collapse of the articular portions may occur, with damage to the articular cartilage. If circulation of the cartilage is not restored, and it dies and becomes eroded, a chronic deforming arthritis is usually established.

Phemister gives an excellent description of the roentgen manifestations of the various stages of the process he has described. "There are no demonstrable changes in the early stages of aseptic necrosis. In case the cause of necrosis is a fracture followed by non-union resulting in marked disuse, there is enough atrophy of the adjacent living bone in one or two months to cause it to cast in roentgenograms a shadow fainter than that cast by the dead bone, which retains its original density. Fibrous tissue invasion of bone causes no change in density, but creeping substitution by new bone alters density. If it takes place in the presence of a considerable degree of

[1] Phemister, D. B. Changes in bones and joints resulting from interruption of circulation. *Arch. Surg.*, 1940, *41*, 436–472.

* Presented at the Eastern Conference of Radiologists, New York, N. Y., Jan. 23–24, 1942.

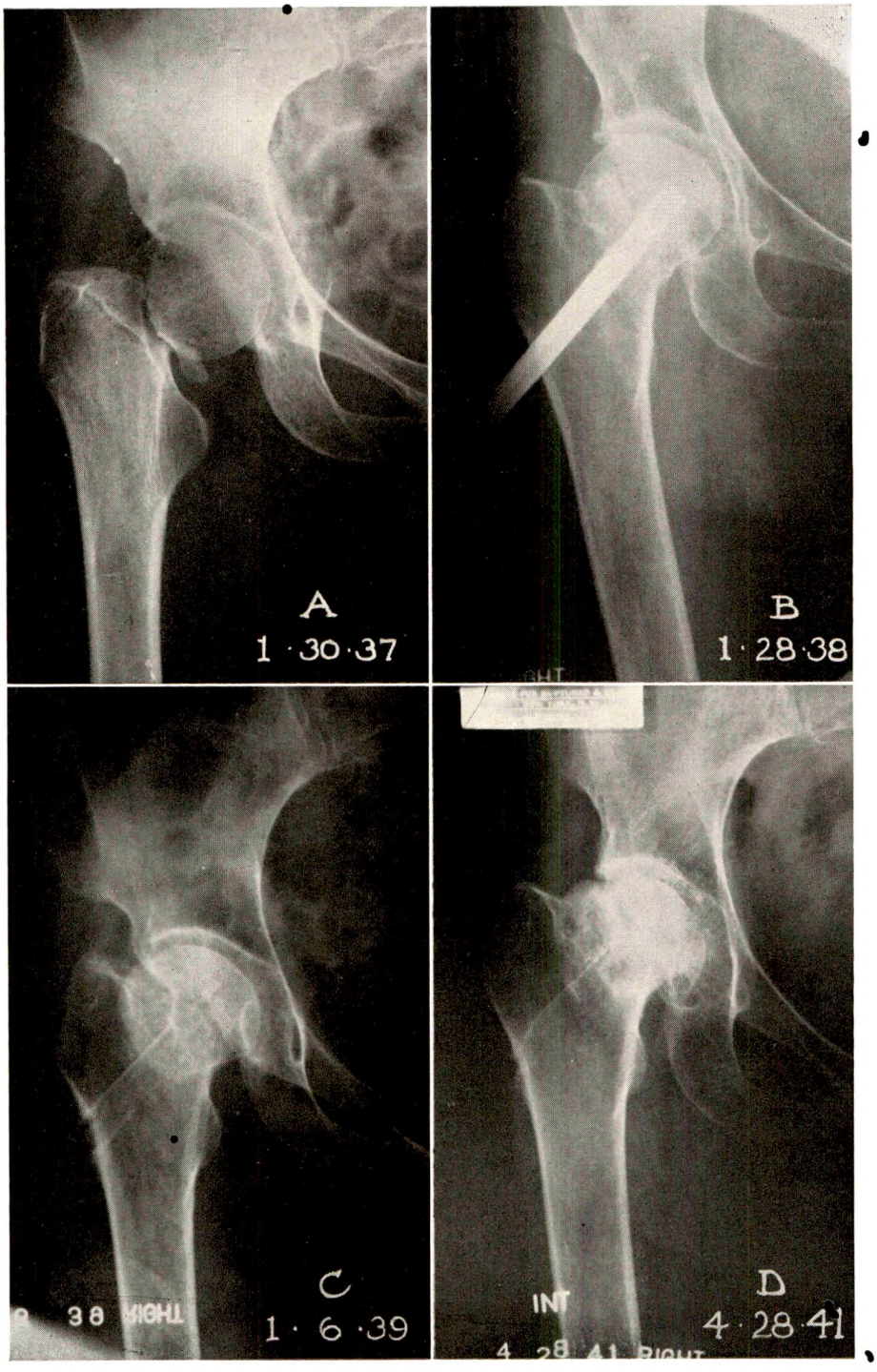


FIG. 1. Case 1. M.H., female, aged fifty-seven. Fell in January, 1937, sustaining a fracture of the femora The fracture was nailed, and roentgenograms over a period of four years show that union was ob but that there was a steadily progressing aseptic necrosis. *A* shows the original fracture. *B* shows pearance about a year later. The proximal fragment is of greater density than the adjacent bon there are small areas of rarefaction indicating very limited creeping substitution. *C* shows the appe about two years after the fracture. Union has taken place, but the reparative processes have been v complete, leaving the major portions of the devitalized head. *D*, taken a little more than four yea the fracture, shows crushing of the head, and fragmentation; and the completely dead upper quad the femoral head has separated, and lies as a large loose body simulating osteochondritis dissecans.

disuse, as in a necrotic femoral head in a case of ununited fracture of the neck of the femur, the new bone is less dense than the old and casts a fainter shadow. In some of these cases central portions of the head may be replaced by fatty bone marrow, which gives the roentgen appearance of a cavity. If, however, there is little or no disuse, the new bone is laid down in greater amounts, and the density approximates the normal But the shadows of the trabeculae are usually irregular, which may suggest the previous existence of a necrotic area. Flattening of the articular surface and fracture lines within or at the limits of the dense bone are important signs. Compression of trabeculae, especially in necrosing lesions in children, may give rise to some degree of increased density." He continues further: "The calcified and ossified line of demarcation which may develop about a stationary necrotic area in the cancellous bone or the medullary cavity of the shaft casts a definite shadow of increased density in roentgenograms. There may also be sufficient calcification within to cause the entire necrotic area to cast a more or less blotchy shadow of increased density."

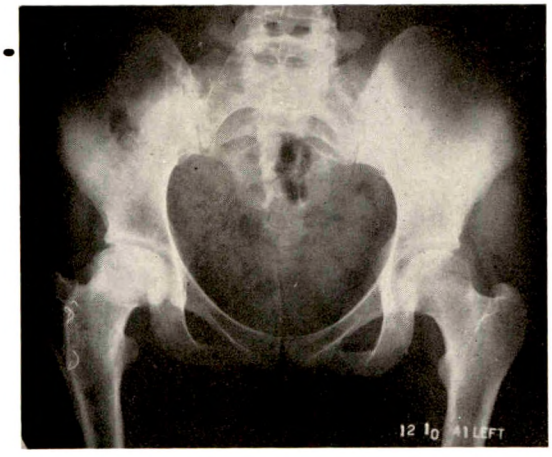


FIG. 2. Case II. J.L., female, aged twenty-six. Twenty-eight months ago she was in an automobile accident, sustaining multiple serious injuries, among others an intertrochanteric fracture of the femur. She was treated elsewhere, the femoral fracture was wired eight days after occurrence, and good union obtained. She was kept from weight-bearing only eight and a half weeks. A review of the roentgenograms taken elsewhere showed no evidence of circulatory disturbance until seven months after injury. From then on until we saw her, the aseptic necrosis was progressive. This was apparently not recognized; and it seems probable that her sutures were regarded as the source of her discomfort, for the accessible portions of these were removed shortly before we saw her. This roentgenogram shows her condition two years and four months after her accident. The femoral head and proximal neck are obviously dead. Central and scattered peripheral rarefactions represent incomplete creeping substitution. The head shows partial collapse. *Comment:* Had the circulatory disturbance been recognized, and function limited, it is theoretically possible that restoration might have been more complete, the crushing of the head prevented, and the now inevitable severe secondary osteoarthritis avoided.

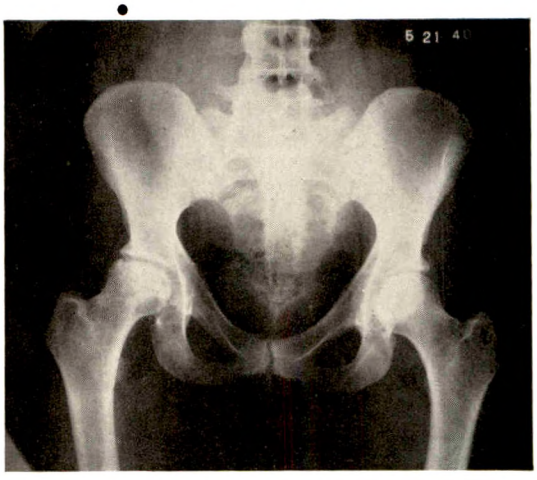


FIG. 3. Case III. D.R., female, aged thirty-two. Former ballet dancer. No history of injury. Was perfectly well until she awoke one morning six months ago with pain in right hip and knee. She has since had mild symptoms in left hip. This roentgenogram shows evidence of circulatory disturbance in both femoral heads, with partial crushing of the right. It seems probable that the etiology in this case was the repeated small traumata incurred during her previous occupation as dancer.

Post-traumatic aseptic bone necrosis is not a rare condition, but, on the contrary, is encountered rather frequently in an active bone and joint service. Its most frequent occurrence is following fractures and dislocations. It is seen occasionally, however, following less serious injury, and we have evidence that it may occur as a result of repeated small traumata such as those

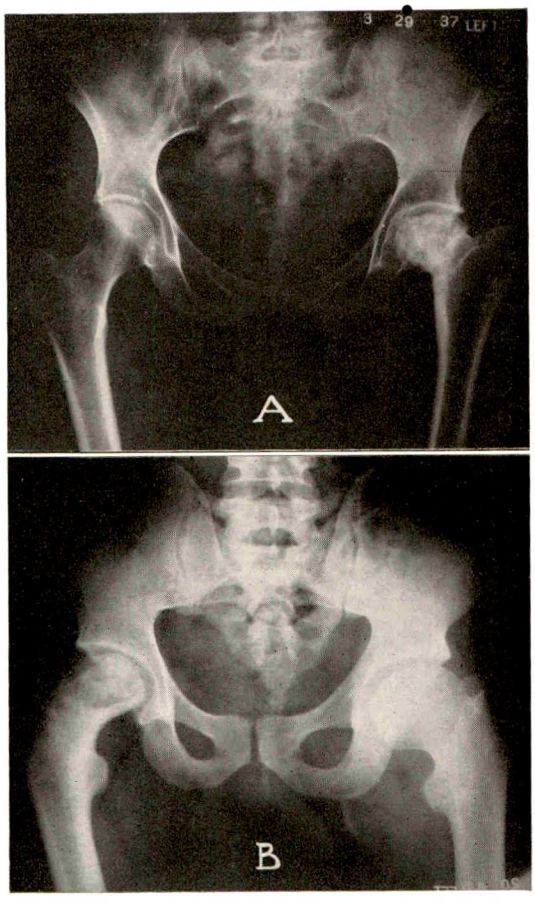


FIG. 4. A warning that other conditions may produce changes simulating aseptic necrosis. *A*, aseptic necrosis; *B*, proven Gaucher's disease.

incurred in ballet dancing. Such a case will be presented.

The most frequent site of occurrence appears to be the upper extremity of the femur, with the carpal bones, tarsal bones and ankle, and elbow in the order of frequency. The time of manifestation of the necrosis is probably variable, dependent on the many variables associated with the different types of trauma. In many instances circulatory changes are evident on the roentgenogram within a few months of the injury. In cases where the aseptic necrosis is not discovered until two or three years after the injury, it seems likely that the changes were present much earlier than this, but were perhaps not recognized. We shall show such a case.

The importance of recognizing the roentgen manifestations of circulatory disturb-

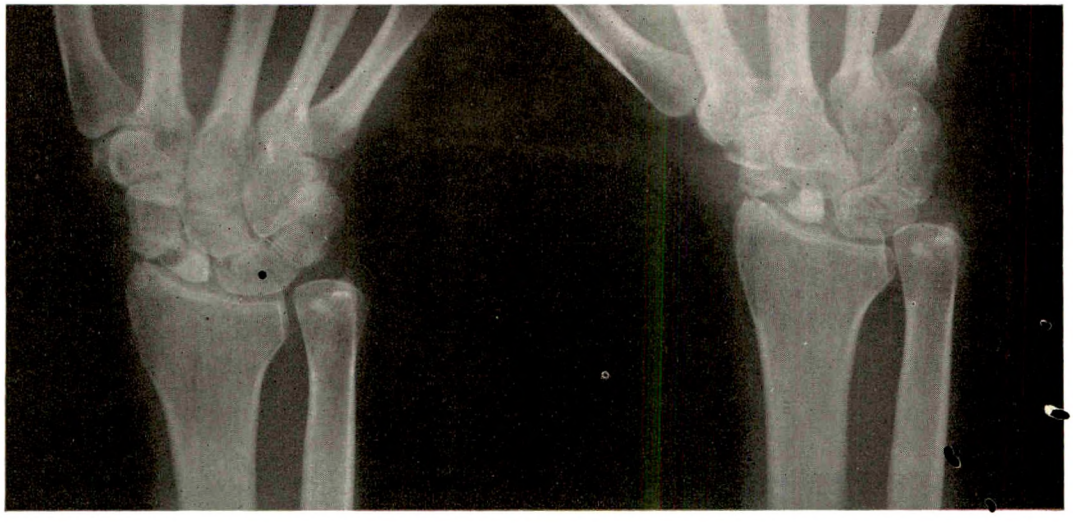


FIG. 5. Case IV. C.T., male, aged twenty-three. Fell from a tree July 17, 1937, sustaining a fracture of the carpal scaphoid. This was treated elsewhere in plaster for ten weeks. Roentgenograms showing non-union, the bone was drilled twice. When seen here February 16, 1938 (Fig. 5) there was non-union, wide separation of fragments, necrosis of the proximal fragment with no evidence of creeping replacement. The likelihood of re-establishing circulation and obtaining union and good function seemed poor. The proximal row of carpals was therefore excised.

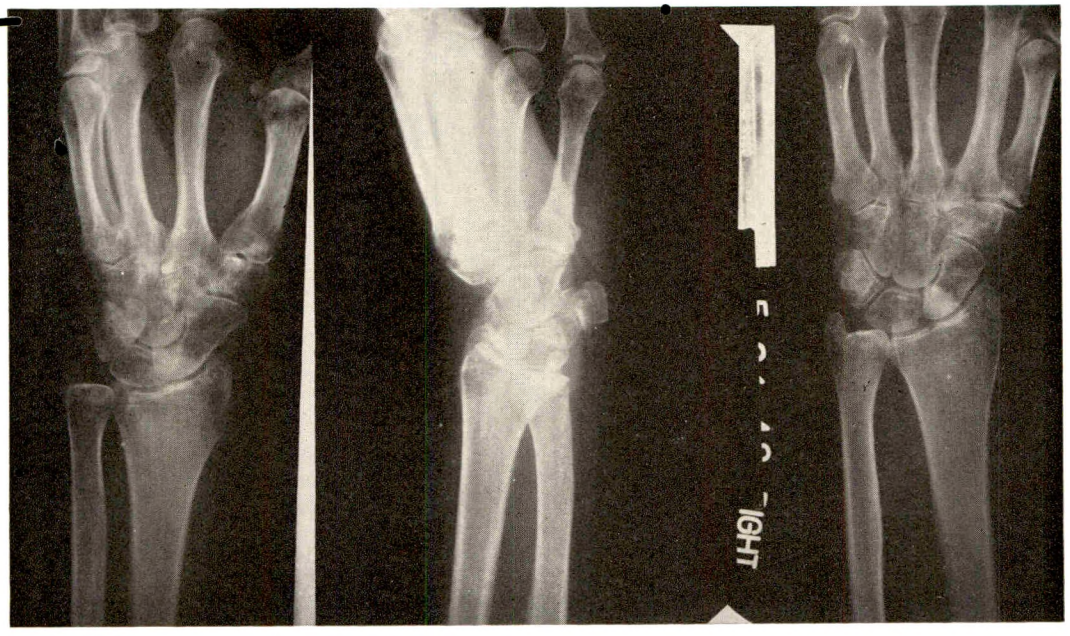


FIG. 6. Case v. M.McC., female, aged forty-eight. Fracture of carpal scaphoid March 1, 1940. Treated in plaster in cockup position for fourteen weeks. These roentgenograms show the condition May 24, 1940. There is evidence of circulatory deficiency in the proximal portion of the proximal fragment, but creeping replacement has occurred in this fragment along the fracture line, with evidence of union. The prognosis seems good.

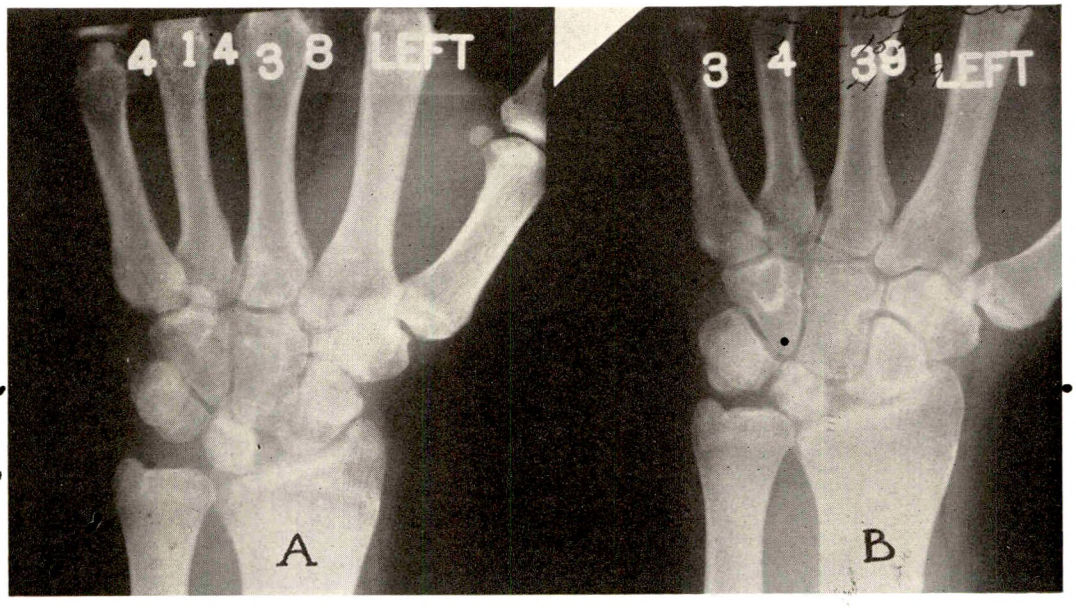


FIG. 7. Case VI. J.M., male, aged twenty-four. November 24, 1937 suffered a dislocation of the lunate bone, but was treated elsewhere only by immobilization. Open reduction was performed in this hospital February 23, 1938. Examination April 14, 1938 (*A*) shows slight subluxation and aseptic necrosis of the lunate. Examination March 4, 1939 (*B*) shows necrosis with small scattered areas of creeping substitution. The prognosis appears unfavorable.

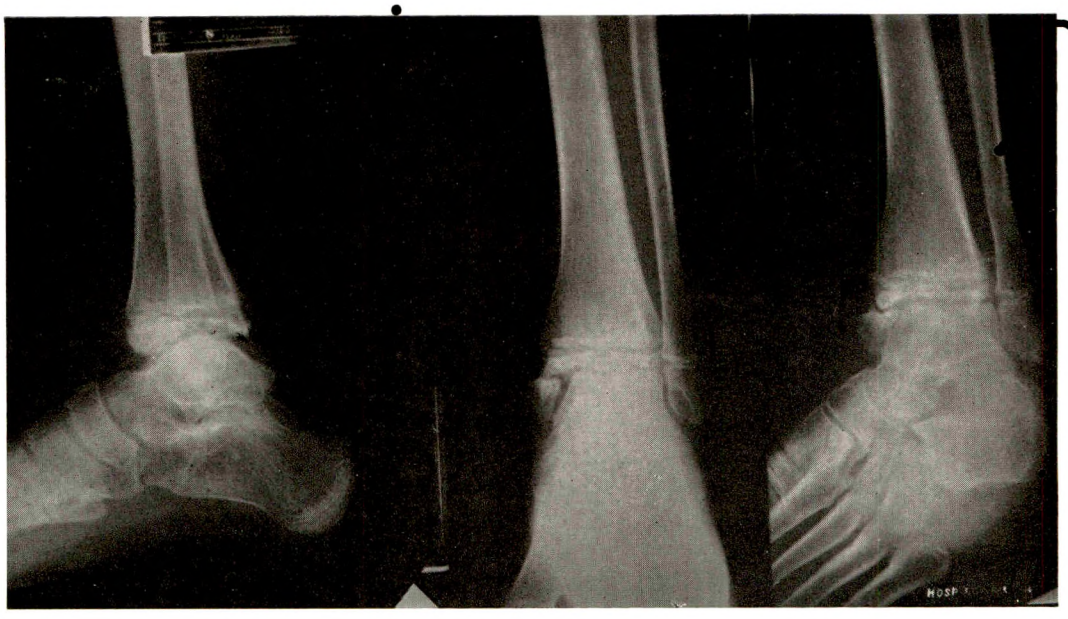


FIG. 8. Case VII. N.H., male, aged twelve. Was run over by car wheel October 31, 1940, injuring ankle. Was in another hospital under treatment for forty-seven days, allegedly for compound fracture of both bones. The wound was said to have closed about a week before he was discharged. These roentgenograms July 23, 1941, show old ununited fracture of the mesial malleolus. The distal epiphysis of the tibia shows irregularly increased density, with much flattening. The epiphyseal cartilage is still present. The ankle joint width is narrow, but not obliterated. The findings suggest aseptic necrosis of the lower tibial epiphysis, with considerable crushing and fragmentation.

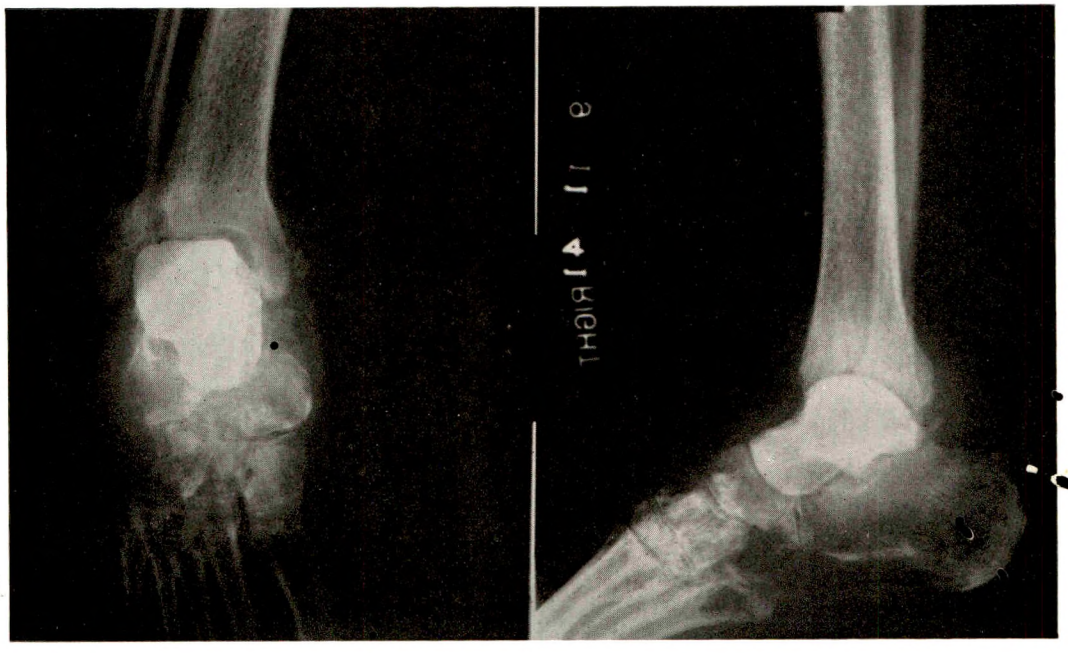


FIG. 9. Case VIII. S.T., male, aged sixty-five. On April 11, 1941, he fell from a roof, sustaining a compound fracture dislocation of the astragalus. Wound was contaminated with dirt, the astragalus seemed to be attached only by a thread. Treated by cleaning, débridement, tetanus antitoxin, sulfanilamide. Infection developed. These roentgenograms show the condition on September 11, with necrosis of the astragalus, probably largely aseptic in nature, with no evidence of creeping replacement. Later examinations showed some evidence of localized areas of creeping substitution, but the eventual outcome is still very uncertain.

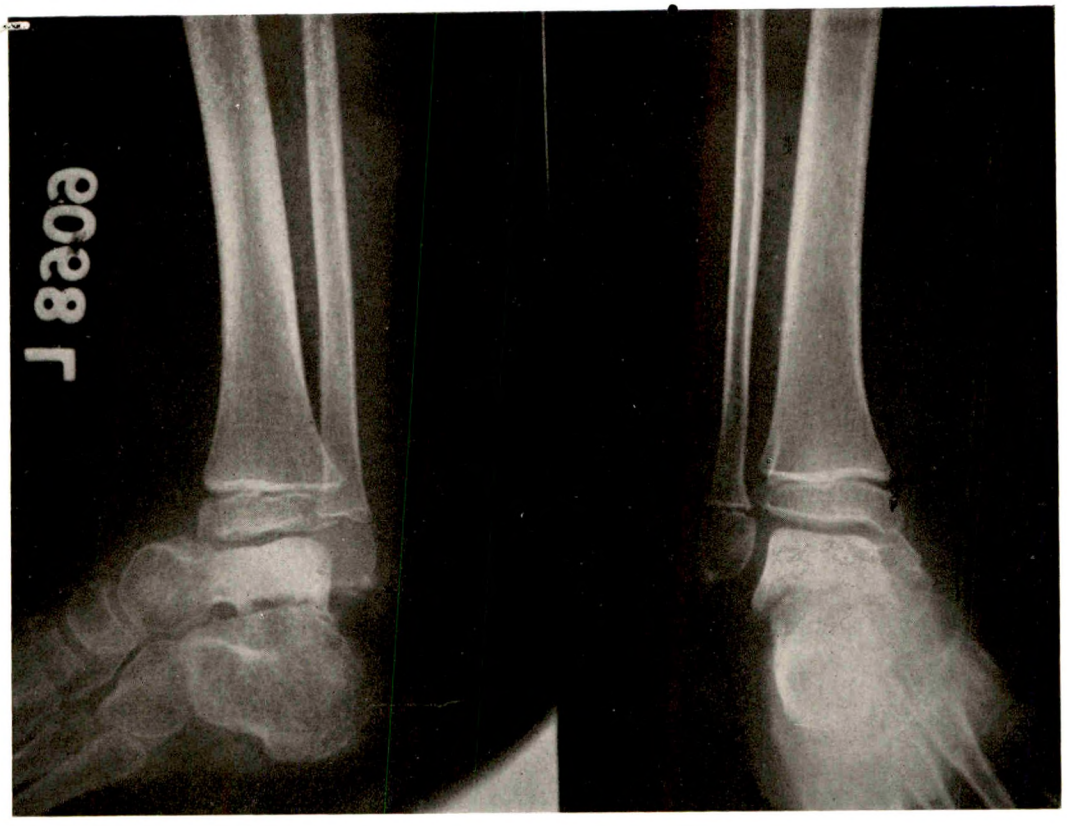


Fig. 10. Case IX. A.B., female, aged six and a half. Was struck by a car, injuring ankle, and was treated in plaster in another hospital about seven weeks. These roentgenograms show the condition two and a half months after the injury. There is obvious aseptic necrosis of the body of the astragalus, with crushing of the body, probably secondary to the circulatory disturbance rather than produced by the original injury. There was little if any evidence of creeping replacement. The patient was treated conservatively, was followed a short time, then disappeared.

ance in bone is obvious. During the period of bone necrosis and creeping replacement, the strength of the bone is greatly diminished, and it cannot perform full function without danger of collapse, without danger of destruction of the anemic overlying articular cartilage. If these things occur, secondary osteoarthritis and a permanently damaged joint seem inevitable. If, on the other hand, the roentgenologist recognizes the existence of deficient blood supply, and the clinician protects the part and restricts function within safe limits, or perhaps carries out some operative procedure to improve circulation, the chances of eventual re-establishment of adequate circulation and restoration of the part to good function are greatly increased.

Figures 1 to 10 are presented showing cases illustrative of the conditions discussed.

SUMMARY AND CONCLUSIONS

(1) A brief summary has been given of the pathology and roentgenographic findings in post-traumatic aseptic necrosis of bone, as described by Phemister in a recent article.

(2) The importance of recognition of the condition by the roentgenologist, and of proper management of the case by the clinician, is discussed.

(3) Cases illustrating the condition are shown and discussed.

(4) As a warning, a case is presented demonstrating that other conditions may bear roentgenographic resemblance to aseptic necrosis.

EXTRAORDINARY CALCIFICATION IN THE BREAST*

By BENJAMIN W. ANTHONY, M.D., *and* HERBERT C. POLLACK, M.D.
CHICAGO, ILLINOIS

DURING our routine examinations we encountered a chest roentgenogram which, on the first observation, showed an unusual network of extreme densities in or on the right side of the thorax, as illustrated in Figure 1. It had the appearance of calcification of the entire right bronchial tree, but under the stereoscope the roentgenograms revealed these calcifications to be in the soft tissues anterior to the bony thorax. Therefore roentgenograms of the

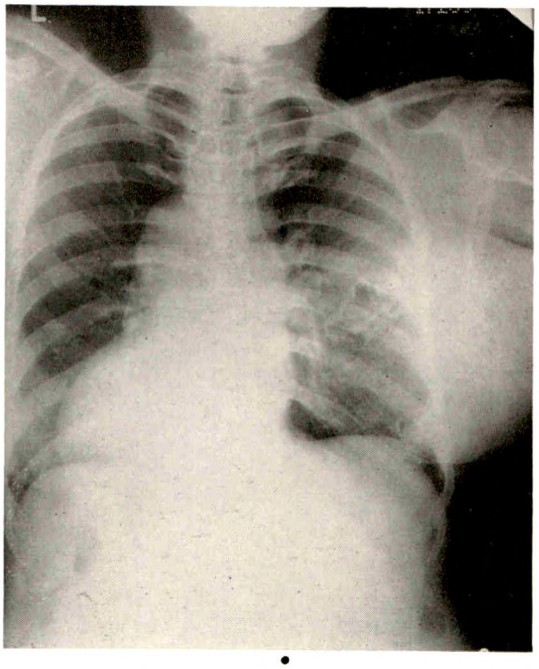


FIG. 1. Right breast grossly enlarged. Calcifications projected through center of right side of thorax.

chest in the oblique diameter (Fig. 2) and of the right breast (lateral and oblique views—Fig. 3 and 4) were taken, demonstrating that these shadows were definitely situated in the right mamma.

Because of the rarity of such findings, we decided to report this case.

The patient was a female, colored, aged sixty-six, who stated that her right breast was injured seventeen years ago by a blow, resulting in pronounced swelling with bluish discoloration and massive hematoma. The breast was extremely painful after the injury, gradually became hard, heavy, and remained so until the present time. She had not observed any remarkable change in the appearance of the breast within the past ten years. On examining the enlarged right breast (Fig. 5 and 6) we noted a heavy, cake-like mass, which measured approximately 2 inches in thickness and $4\frac{1}{2}$ inches from the medial to the lateral borders. The firm mass felt as if it were composed of concrete. The breast was pendulous, freely movable over the underlying tissue, and so heavy that it had to be elevated and supported during our roentgenographic studies. There was no retraction of the nipple and the skin of the breast showed no pathological changes. The regional lymph nodes were not palpable; the surface of the breast was uniform and no pain was elicited on palpation.

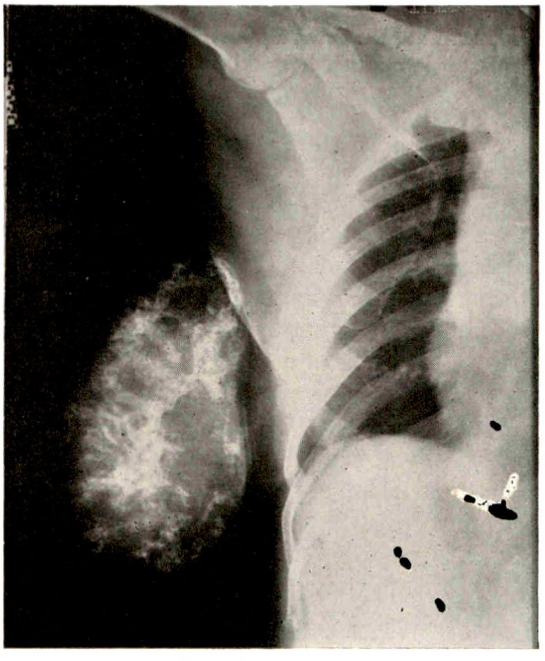


FIG. 2. Extensive calcifications and ossifications within the right breast. Thoracic cage and lungs clear.

* From the Department of Roentgenology, Provident Hospital, Chicago

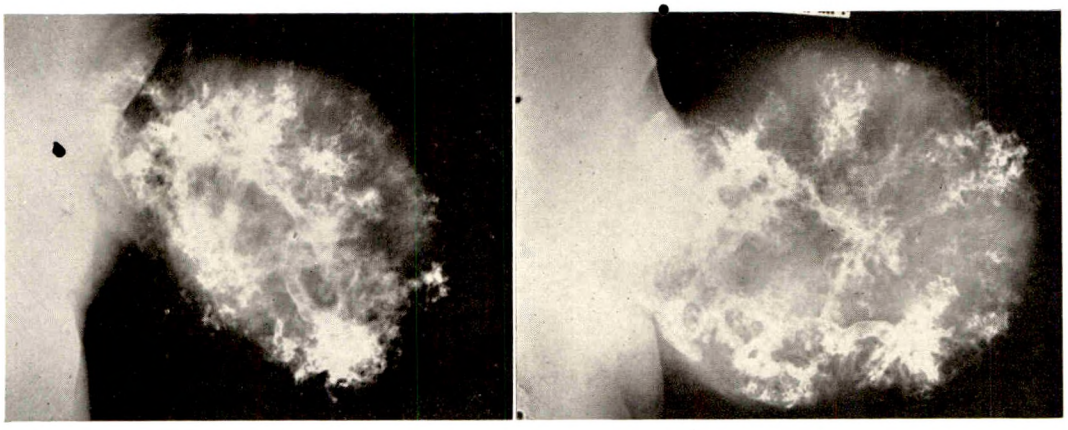


Fig. 3 and 4. Right breast. Oblique and lateral views. Radiating trabecular arrangement of ossifications and calcifications.

Ordinarily the breasts of a woman of this age are atrophic and this applied to the left mamma, which was normal. The roentgenograms showed pronounced calcifications involving almost the entire right breast, branching from the base to the periphery in a shrub-like manner. In the central portion ossification was present, radiating in all directions throughout the right breast, showing a tendency toward bone formation. The oblique as well as the lat-

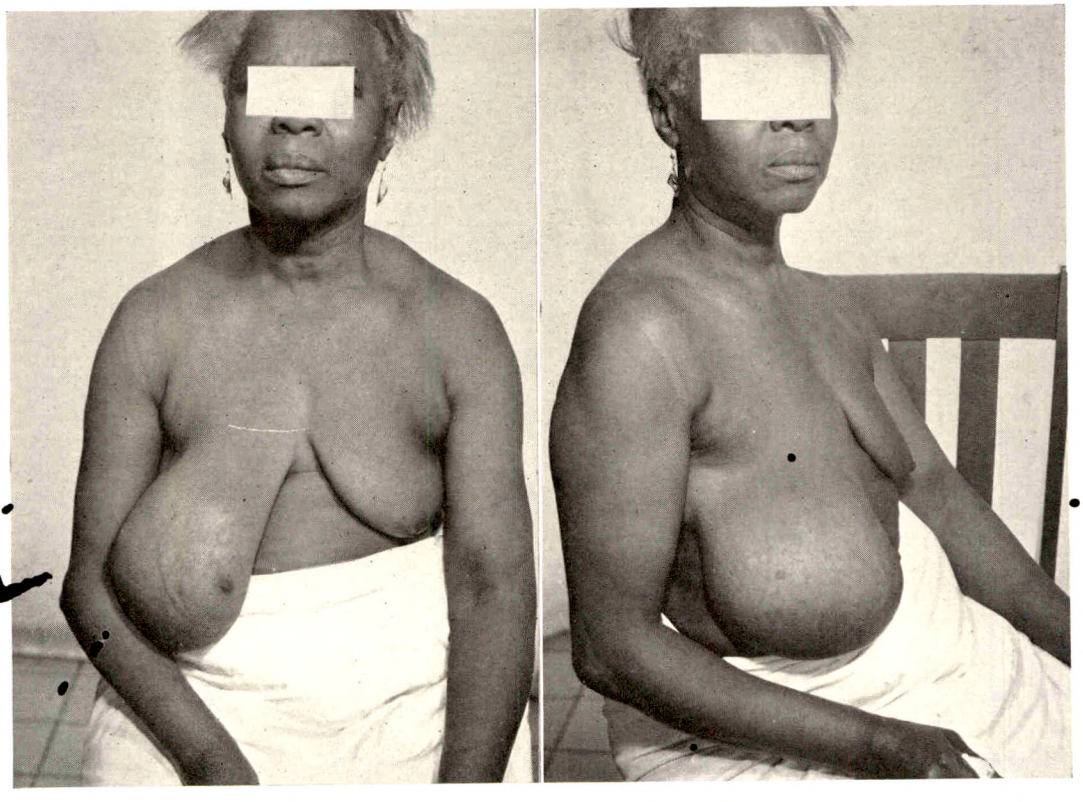


Fig. 5 and 6. Frontal and oblique photographs of breasts. Right is grossly enlarged and pendulous, whereas the left one is atrophic.

eral views of the breast revealed that the calcification extended from the soft tissue and did not involve the bony cage.

The literature of the last ten years discloses that roentgen examinations of the breast have been of diagnostic value in differentiating between benign and malignant lesions of the breast. There are numerous conditions followed by calcification in the breast, the most frequent of these being healed mastitic abscesses. In addition, calcification may occur or be associated with the following affections:

1. Adenoma
2. Cyst
3. Hematoma
4. Mammary tuberculosis
5. Psammocarcinoma
6. Necrotic areas of mammary carcinoma
7. Calcinosis universalis
8. Osteitis deformans

Calcium deposits may be in any part of the breast, in the subcutaneous and fatty tissue, in the parenchyma, or in the "milk ducts" radiating from the nipple to the base of the breast.

Calcifications in carcinomatous tissue, however, are extremely rare whereas our observations confirm the fact that calcareous deposits are relatively common in benign lesions.

SUMMARY

A case is presented exhibiting extensive calcification of almost the entire right breast in a female aged sixty-six. Presumably these changes were the result of trauma and hematoma formation having occurred seventeen years previously. This is the most extensive calcification we have been privileged to see in our experience.

REFERENCES

1. FINSTERBUSCH, R., and GROSS, F. Kalkablagerungen in den Milch- und Ausführungsgängen beider Brustdrüsen. *Röntgenpraxis*, 1934, 6, 172–174.
2. LEDOUX-LEBARD, R., GARCIA-CALDERON, J., and ESPAILLAT, A. Étude radiographique de la glande mammaire. *Bull. et mém. Soc. de radiol. méd. de France*, 1933, *21*, 418–432. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 265.
3. LOCKWOOD, I. H. Roentgen-ray evaluation of breast symptoms. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 145–155.
4. PASCHETTA, V. Étude radiologique de la glande mammaire. *Bull. et mém. Soc. de radiol. méd. de France*, 1931, *19*, 346–348. Abs. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *29*, 553.
5. REMY-ROUX. Sur un cas de granulations calcaires sous-cutanées. *Bull. et mém. Soc. de radiol. méd. de France*, 1932, *20*, 437–440. Abs. AM. J. ROENTGENOL. & RAD. THEARPY, 1933, *30*, 567.
6. WARREN, S. L. Roentgenologic study of the breast. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 113–124.

VOL. 49, NO. 5

OSTEOPOIKILOSIS*

A CASE REPORT

By ROY H. THOMPSON, *Lieutenant Colonel, Medical Corps, Army of the United States*
RUBEN HOOVER, *Major, Medical Corps, Army of the United States*
FORT HAYES, OHIO
and
HUSTON F. FULTON, M.D.
COLUMBUS, OHIO

THE following case of osteopoikilosis (osteopathia condensans disseminata) is presented because of the apparent rarity of this entity and because this case may aid in furthering its study.

On October 31, 1941, the Selective Service Examining Board at Fort Hayes, Columbus, Ohio, was confronted with another problem. This was in the form of a husky, well built, well nourished applicant, J.B.L., who complained, as did so many others, of vague pains. These were localized to the right hip and right knee. He was given the usual tests and no deformity or limitation of motion or areas of tenderness were noted. He was given the benefit of the doubt and referred to the roentgen-ray clinic at the Station Hospital. The diagnosis of osteopoikilosis was returned and the applicant admitted on November 1, 1941, for further study.

The applicant was a white male, aged twenty-seven, and weighing about 180 pounds, and was a native Ohioan. After leaving the seventh grade at the age of sixteen he worked on his father's farm. He was an occasional user of alcohol and tobacco. No history of drug addiction was admitted. About two years previous to his admission he stated that after a hard day of work he noticed a heavy feeling in his right leg and a dull ache in the right hip. This pain would disappear after a night's rest. No trauma was remembered which could account for the onset of the pain. Since then every day that the work was particularly heavy the ache would return. There seemed to be no difference in the severity of the pain felt on admission as compared with that at the onset. The history taken on admission revealed that the father was living and well at sixty-three years of age. The mother had died of tuberculosis at the age of sixty-three. Three brothers and two sisters were living and well. Among the childhood diseases recalled

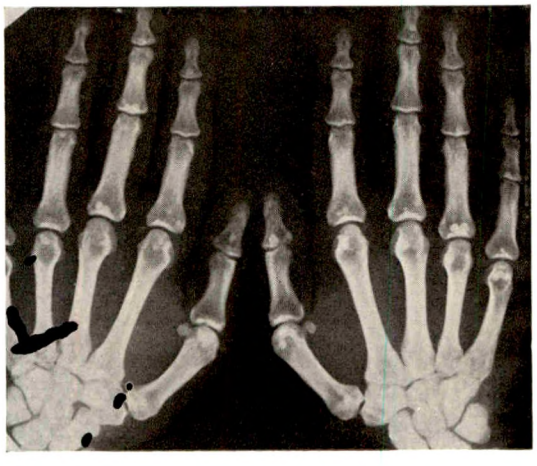


FIG. 1. Osteopoikilosis. The dense circumscribed areas are diffusely scattered through the carpal bones but are confined to the ends of the long bones.



FIG. 2. The dense circumscribed areas are present in the body of the fifth lumbar vertebra, sacrum, pelvis, and upper end of the shafts of the femurs, concentrated more at the weight-bearing points.

* Published with permission of the Surgeon General who is not responsible for any opinion expressed or conclusions reached herein.

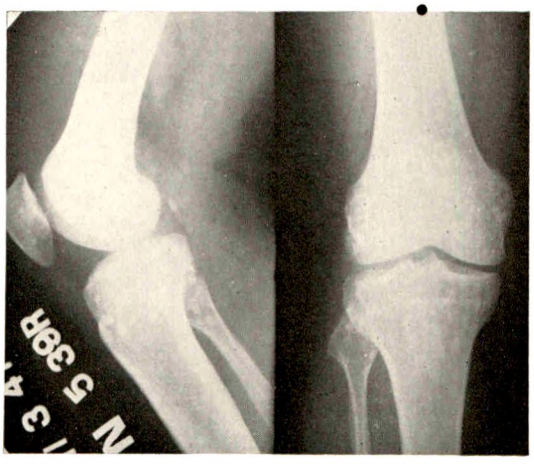


FIG. 3. Areas of osteopoikilosis noted in and near the articular surfaces of the tibia, fibula, femur, and patella.

were measles, mumps and whooping cough. No serious operations or injuries were remembered.

The physical examination was essentially negative. The eye grounds were normal. The cardiovascular system was normal and the blood pressure 134/85. The prostate gland was normal. No lymphadenopathy was present. The reflexes were normal.

The laboratory report revealed a blood calcium of 15.6 mg. per 100 cc. The blood phosphorus determination was unsatisfactory and owing to brevity of the time available for the study, the test was not repeated. The blood sugar was 85 mg., non-protein nitrogen 30 mg., and chlorides 220 mg. per 100 cc. The blood study showed 4,860,000 red blood cells, 6,900 leukocytes and a hemoglobin of 90 per cent. The differential count showed 60 per cent polymorphonuclears, 37 per cent lymphocytes and 3 per cent eosinophiles. The Kahn test was negative. Urinalysis was negative for albumin; a trace of sugar was found. The urine was straw colored, clear, acid, and microscopically negative.

The roentgen report was as follows: *Skull:* Right lateral stereoscopic view shows the sella to be small and bridged. No evidence of osteopoikilosis*. *Chest:* Small mass of calcified right paratracheal nodes measuring about 1.5 cm. in diameter. Calcified primary tubercle in right apex. No evidence of activity or of reinfection type tuberculosis. No evidence of osteopoikilosis. *Pelvis:* Small dense sharply demarcated areas present throughout pelvis including upper ends of femurs and fifth lumbar vertebra, more numerous near the joint surfaces, and not elevated above the surface of the bone, measuring from 2 to 5 mm. in diameter. *Knees:* Small dense sharply demarcated areas present in cortex of diaphysis and epiphysis, most numerous in the latter, of all bones in both knees including the patellae. *Feet:* Similar areas present mainly near the articular surfaces of the long bones and scattered uniformly through the tarsal bones. *Hands:* Similar areas present in the bones of both hands†.

Ferguson[1] states that defective bone formation in the metaphysis takes the form of dense non-reticulated calcareous matter. The central intermittent defect of this type gives rise to a persistent, dense, structureless area in the bone, sometimes small and rounded, characterized by abrupt transition from normal apparently healthy bone to absence of reticulation in the dense area. When this is diffuse, widespread, and abundant it is called osteopoikilosis. These defects are innocuous.



FIG. 4. Similar distribution of osteopoikilosis involving both feet.

* The sella turcica measured 8 mm. in the anteroposterior diameter and was 6 mm. deep, at a 30 inch film tube distance.

† Since submission of the paper the father was roentgenographed for study of the pelvis and long bones and the roentgenograms showed no evidence of osteopoikilosis.

According to Hirsch's[2] classification, this case would be of the nodular variety. Nichols and Shiflett[4] described a case complicated by hypopituitarism, in which the sella turcica, as in this case, was small but otherwise normal. Several investigators have verified its hereditary tendency; among them are Wilcox,[6] Sutherland,[5] and Lowrey and Booth.[3]

This case was apparently free of complications although a definite slight mental deficiency was noted. The fact that the mother died of tuberculosis may be of some significance.

An unsuccessful attempt was made to have the family undergo physical and roentgen examination. This applicant was rejected because of his joint pains which were believed to be severe enough to preclude full military service.

REFERENCES

1. FERGUSON, A. B. Roentgen Diagnosis of the Extremities and Spine. *Ann. Roentgenol.*, Vol. XVII. P. B. Hoeber, Inc., New York, 1941.
2. HIRSCH, I. S. Osteopoikilosis. *Radiology*, 1935, *25*, 349–354.
3. LOWREY, J. M., and BOOTH, J. H. R. Osteopathia condensans disseminata: "spotted bones." AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *37*, 774–781.
4. NICHOLS, B. H., and SHIFLETT, E. L. Osteopoikilosis. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 52–63.
5. SUTHERLAND, C. G. Osteopoikilosis. *Radiology*, 1935, *25*, 470–479.
6. WILCOX, L. F. Osteopoikilosis (disseminated condensing osteopathy). AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *27*, 580–584.

THE ROENTGEN TREATMENT OF CANCER OF THE ESOPHAGUS

By D. W. SMITHERS, M.D., D.M.R., J. R. CLARKSON, PH.D., *and* J. A. STRONG,* M.Sc.
From the X-Ray and Physics Departments of the Royal Cancer Hospital (Free)
LONDON, ENGLAND

INTRODUCTION

By D. W. Smithers

THERE are good reasons for believing that the treatment of cancer of the esophagus should meet with more success than it has done in the past. One of the essentials for such progress is an understanding of the peculiar difficulties which are associated with the treatment of this disease. Improvement is only to be expected if we can take steps to eliminate or minimize the effects of many of the factors that have contributed to our past lack of success.

Reasons for Failure of Treatment Due to the Nature of the Disease.

1. The great majority of patients with cancer of the esophagus do not receive any treatment until the disease has been present for many months.

2. The esophagus is a thin-walled, deep-seated tube, which may be extensively involved by the tumor and which lies in close relation to vital structures, perforation into which results in rapid death.

3. A cancer of the esophagus is often a highly malignant growth which, although the majority remain localized for a few months, tends to rapid and widespread dissemination in the later stages.

4. Esophageal obstruction leads to starvation and such rapid deterioration in the patient's general health that his ability to withstand the strain of any radical treatment is seriously impaired.

The disease is often well advanced by the time that it causes sufficient obstruction for the patient to notice difficulty in swallowing. As dysphagia is the commonest initial symptom it is seldom possible to make the diagnosis at an early stage. It is therefore all the more important that treatment be started without delay once symptoms have appeared. At present there is a gap of several months before the majority of these patients reach the hospital (Table 1). The chances of success with any treatment must undergo a serious deterioration during this wasted period.

TABLE I

AVERAGE DURATION OF SYMPTOMS BEFORE ADMISSION TO HOSPITAL

Observer	Time in Months
Abel[1]	6 to 8
Souttar[29]	5.2
Broders and Vinson[5]	7.0
McGibbon[18]	3.4
Present series	4.1

In general the difficulties with any form of treatment increase with the size of the tumor. In many of these cases a considerable length of the esophagus is involved. In 2 of the untreated cases in the present series a tumor 7.5 cm. in length was found at autopsy after a period of six months' dysphagia. In another the patient had had symptoms for four months and two ulcers were found, one 4.5 cm. long and the other 11 cm. long, separated by a small piece of apparently normal mucous membrane. Buchbinder[6] examined 33 cases where the average duration of symptoms had been five and one-half months and found that the average length of esophagus involved was 7.5 cm. Fleming[10] found tumors of an

* We regret that since the completion of the text of this paper, J. A. Strong was killed on active service with the Royal Air Force. Mr. Strong was physicist to the New Zealand Branch of the British Empire Cancer Campaign, and his death is a severe loss to medical radiology.

average of 5.4 cm. in length in 34 cases. The relationship between the size of the tumor and the duration of symptoms in his cases is shown in Table II.

Table II (Fleming[10])

Relationship between size of primary growth and duration of symptoms before death

Size up to:	Cases	Average Survival in Months from Onset of Symptoms
2.5 cm.	2	4.5
2.5– 5.0 cm.	12	5.5
5.0– 7.5 cm.	13	5.4
7.5–10.0 cm.	5	5.3
10.0–12.5 cm.	2	5.8

Esophageal tumors tend to be of the less well differentiated, more highly malignant grades. McGibbon[18] collected some figures showing the proportion of cases in each grade (Table III). The more undifferentiated the tumor the greater its tendency

Table III (McGibbon[18])

Observer	No. of Cases	Grade 1	Grade 2	Grade 3	Grade 4
Broders and Vinson[5]	207	0	16	95	96
Watson[33]	202	15	148	39	0
Clayton[9]	39	3	15	12	9
Percentages	—	4%	40%	32.5%	23.5%

to rapid dissemination. Clayton[9] collected data to demonstrate this point (Table IV). The length of time that symptoms have been present must be considered together with the grade of the tumor in assessing the chances that distant metastases are present. The importance of the length of history in this respect was stressed by Helsley.[12] The average duration of symptoms in his patients who died without demonstrable metastases was 4.84 months. Those patients of his who had had a gastrostomy lived an average of sixty-nine days longer than the remainder, and the percentage with metastases rose during this period from 18 to 43. In the present series postmortem examinations were carried out in 13 (7 treated and 6 not treated or incompletely treated). No metastases were found in 4 who had lived an average of five months since the onset of symptoms but metastases were found in nine that had lived an average of 9.1 months.

The great majority of these patients on arrival at the hospital are already weak and wasted, most of them have extensive involvement of the esophagus, many have distant metastases and some may be expected to perforate before any adequate

Table IV (Clayton[9])

Incidence of distant metastases according to the grade of tumor and duration of symptoms

Grade	No. of Cases	Average Duration of Symptoms before Death in Months	No. of Cases with Metastases
1	3	16	1 (33.3%)
2	15	8	10 (66.7%)
3	12	5	10 (83.3%)
4	9	2.5	9 (100%)

treatment can be given. So long as the present delay in starting treatment persists nothing more than an occasional success can be expected with any treatment.

There is probably little that can be done to persuade these patients to report their symptoms earlier, but the removal of the impression held by so many practitioners that no benefit results from treatment may help to speed their progress to a hospital. There is evidence that success can be achieved in an increasing proportion of cases, and much can be done to relieve symptoms and prolong life. One has only to see a few of these patients able to swallow normally once more to be convinced of the value of treatment on this score alone. Great care should be taken in the examination of any patient who has symptoms that might be due to a cancer of the esophagus. As soon as the diagnosis is made every precaution must be taken to avoid local trauma which may increase the risk of perforation. It is important that these patients

should receive adequate nourishment.

A case recently published by Bendick[4] is a good example of what can be achieved with early diagnosis and treatment. In this case the diagnosis was made and confirmed microscopically before obstruction had occurred and the patient was alive, well and working two and one-half years after Garlock had resected the esophagus. The tumor was found to be but 2.0 by 1.4 cm. in size.

Particular Difficulties Associated with the Various Methods of Treatment.

1. *Surgery.* The surgical removal of esophageal tumors carries a high operative mortality and is still only applicable to a very small proportion of cases. Adams and Phemister[2] in 1938 collected the published cases of successful removal of tumors of the thoracic and abdominal esophagus and could find only 36 from 1907. Of these 36 only one lived more than five years. This oft quoted and fascinating case was published by Torek.[31,32] The patient lived for thirteen years and then died of intercurrent disease. It is of interest to note that this one success was achieved in a most unusual case for the growth had remained localized despite the fact that symptoms had been present for as long as nine months. The risks of operation and the past lack of success even with selected cases suggests that surgery is only indicated for some tumors of the cervical portion of the esophagus or where exceptional circumstances are present.

2. *Teleradium.* Owing to the inadequate depth dose obtainable with the teleradium units at present in use, this method of treatment is not suitable for deep-seated tumors. (Five gram teleradium unit $d\frac{1}{2}$ = 3.4 cm.; 400 kv. roentgen unit used as described in text $d\frac{1}{2}$ = 7.1 – 7.9 cm.) ($d\frac{1}{2}$ is the depth below the surface along the central axis of the beam at which the dose is 50 per cent of that received on the surface.) As far as the esophagus is concerned teleradium therapy must be confined to tumors of the cervical portion.

3. *Interstitial radium or radon.* The implantation of radium or radon cannot be carried out accurately through an esophagoscope; the instrument distorts the tissues and the seeds can only be inserted obliquely. It is almost impossible to place the radon so as to obtain an even irradiation of the whole tumor. The trauma and local high dosage inherent in this method increase the risk of perforation. It is only of value where surgical exposure can be obtained comparatively easily, as in the case of tumors of the fundus of the stomach which involve the lower limit of the esophagus.

4. *Radium bougie.* The best results have so far been obtained by the use of the radium bougie. The outstanding exponent of this form of treatment is Guisez. Some of his results are quoted by Watson[33] (Table v). Guisez[11] also refers to one of his patients who lived for twenty-six years after treatment. Lawrence Abel has shown the present writer the unpublished records of one of his patients, treated at the Royal Cancer Hospital in April, 1927, who died of intercurrent disease in December, 1938.

TABLE V (Guisez)

RESULTS OF INTRA-ESOPHAGEAL RADIUM TREATMENT OF 270 CASES OF CARCINOMA OF THE ESOPHAGUS

1	alive 11 years after treatment
1	alive 10 years after treatment
1	alive 5 years after treatment
4	alive 4 years after treatment
4	alive 3 years after treatment
12	alive more than 18 months after treatment without evidence of disease

4 died of intercurrent disease without evidence of recurrence

The disadvantages of the radium bougie are the difficulty in passing the upper limit of the obstruction, the rapid fall off of dose with depth, and the local trauma and high dosage which increase the risk of perforation. Zuppinger[34] treated groups of these patients with radium bougies, roentgen irradiation and combinations of the two. He found that the incidence of perforation

was higher with intra-esophageal radium and obtained the best results with roentgen irradiation alone.

5. *Roentgen irradiation.* Zuppinger[34] reported that 2 of his patients were alive, well and symptom free two and one-half years after roentgen treatment. Nielsen[25] attempted to give an adequate tumor dose in 17 cases, 8 of these lived more than one year, 2 were alive and symptom free at the end of three and one-half years and one at two and one-half years. Malcolmson and Malcolmson[19] reported one patient alive and well three years and Baum[3] one six years after treatment. Hilton[13] published particulars of a case in 1937 that had survived over three years and she informs me (July, 1940) that this patient is still alive and well. The disadvantages of roentgen irradiation are that a large volume of normal tissue must be irradiated, that damage may be done to these tissues and that the tumor dose which can be given is limited by the total energy absorption that the patient will tolerate.

The Advantages of Roentgen Treatment.

Roentgen treatment has much to recommend it for it is the most effective method of securing palliation and at the same time causes the patient least discomfort. These considerations are of great importance in a group of patients in which only a limited success can be expected. Roentgen treatment allows of an even irradiation of the whole tumor without local trauma. Measures can be adopted to overcome, in part, the main disadvantages of the method. To obtain a maximum tumor effect for a minimum damage to normal structures, it is essential to pay very careful attention to obtaining the optimal distribution of the radiation in the whole volume irradiated. This can be done by studying the three-dimensional distribution of the radiation due to various field arrangements and attention to the detail of the accurate application of the final fields selected. By such means we may hope to deliver an adequate tumor dose without overstepping either the limit of total energy absorption that the patient can tolerate or the dose to normal tissues that will cause serious damage. Recent work at the Royal Cancer Hospital has been concerned both with volume distributions of radiation[14] and with total energy absorption.[23] This work has now been applied to the problem of the roentgen treatment of cancer of the esophagus. The results obtained not only show that palliation and prolongation of life can be obtained in many cases, but also that the disease can be eradicated in some cases if the patients are treated early enough.

The assessment of the relative values of the various methods of treatment is a matter of extreme interest. If comparison is to be made complete accounts of all patients seen whether treated or not must be published for each method adopted. The purpose of the present paper is to describe in detail the method of roentgen treatment employed at the Royal Cancer Hospital and to give an account of the subsequent history of all cases seen from 1936 to 1939.

PART I

DESCRIPTION OF THE METHOD OF ROENTGEN TREATMENT ADOPTED AT THE ROYAL CANCER HOSPITAL AND AN ACCOUNT OF THE RESULTS OBTAINED

By D. W. Smithers

Classification. After the patient has been carefully examined and an esophagoscopy and a roentgenological examination performed we may, by taking into consideration the patient's general health, the length of history, and the degree of differentiation of the tumor, arrive at a fairly accurate assessment of the chances that the patient will benefit materially from treatment. As some palliation is to be expected in the majority of cases, treatment should be attempted whenever possible, but at times it is clear from the start that little or nothing can be done. In the present series treatment was started whenever the patient was well

enough to be brought to the department and could remain still supported in a sitting position for approximately one hour each day. If treatment was started at all the patient was placed in the treated group but a distinction was made between those that did and did not complete the treatment prescribed. The patients, therefore, were divided as follows:

1. Not treated.
2. Treated
   (a) completed treatment.
   (b) failed to complete treatment.

The arrangement of fields adopted for the treatment of tumors of the upper limit of the esophagus was the same as that employed for postcricoid tumors of the pharynx, and the arrangement for the lower limit of the esophagus was the same as that for tumors of the stomach in the region of the cardia. From a roentgen treatment point of view these cases were therefore divided according to the site of the tumor as follows:

1. Postcricoid tumors and tumors of the cervical esophagus.
2. Tumors of the thoracic esophagus.
3. Tumors of the abdominal esophagus and of the fundus of the stomach involving the esophagus.

Tumors of the esophagus were also divided according to the third of the organ in which the main body of the tumor lay for comparison with other work. McGibbon[18] took the mean percentages for each third from seventeen published series and found 17 per cent upper third, 47 per cent middle third and 36 per cent lower third tumors. It is probable that this represents a rather high percentage of lower third tumors. The majority of the tumors involving the lower limit of the esophagus are primary tumors of the stomach which invade the esophagus. In many cases the gastric portion of the tumor can be demonstrated roentgenologically. Histological examination is also helpful but adenocarcinomata do occasionally arise from "cardiac glands" in the esophageal mucosa or from patches of ectopic gastric epithelium.

Tumors of the Thoracic Esophagus.

1. *Preparation of the patient and care during treatment.* Whenever possible an esophagoscopy is performed before treatment is started and a piece is taken for biopsy so that the diagnosis can be confirmed and the degree of differentiation of the tumor determined.

If esophageal obstruction is almost complete, and the patient can swallow nothing but sips of fluid, a preliminary gastrostomy is performed. It is not done as a routine, as even this operation has a certain mortality in this group of weak and debilitated patients, and swallowing improves in the second week of roentgen treatment in nearly every case.

A calorie chart is kept for each patient to show the daily food intake, to serve as a guide to progress, and to impress the nursing staff with the importance of adequate nourishment. Each patient is weighed at regular intervals. Figure 1 is a dose, weight, blood count and calorie chart for an actual patient during the treatment period. The diet must be a fluid one in most cases, at any rate for the first two or three weeks. It should be given in small frequent, concentrated feeds containing a good proportion of protein and having a high vitamin content. Feeds should be given at least at three-hour intervals during the day and once during the night if the patient is awake.

All these patients should be in hospital throughout their treatment. It is important to see that they get adequate rest and to keep a check on the temperature and pulse rate. Levitt[17] has pointed out the importance of the pulse rate; a persistently rapid pulse, usually without pyrexia is regarded by him as the first sign of mediastinitis and of serious import. We have been able to confirm this in several cases. Patients with severe and persistent tachycardia seldom complete their treatment and rarely survive it by more than a few weeks.

This tachycardia may be followed by substernal pain, with fever in some cases, and commonly ends with perforation of the esophagus.

It is important to keep a record of the variation in the patient's blood count, for it is here that the first indication appears that the patient's tolerance to large volume must be taken to raise it; the most effective means is to stop treatment for a few days. This is to be expected for the drop in the white cell count is partly due to a destruction of circulating lymphocytes. The problem is an important one for the leukopenia produced is a major obstacle in the way of adequate roentgen treatment. Carrié[7]

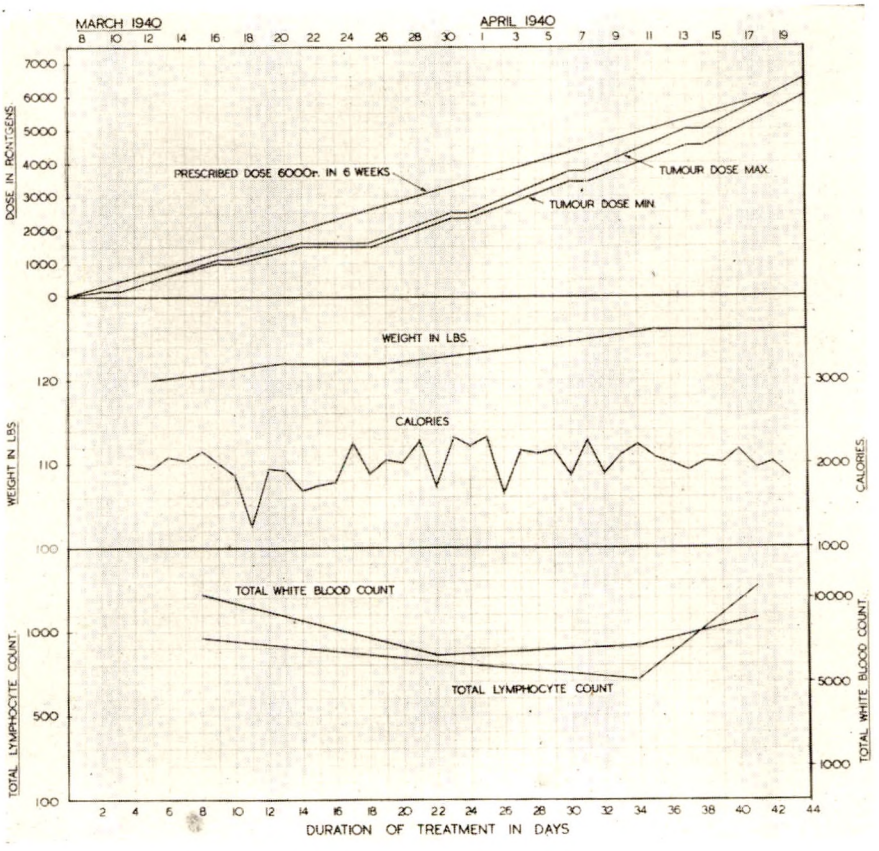


Fig. 1. Tumor dose, weight, calorie and white blood count chart. The record of an actual case during the treatment period.

irradiation is failing. Blood counts are therefore carried out before treatment and at weekly intervals throughout the course or more frequently if necessary. With such a fatal disease risks may be taken so we do not stop treatment unless the total white cell count falls below 2,000 cells per c. mm. or the lymphocytes below 200 cells per c. mm., and the treatment is continued as soon as the blood count improves. When this drop in the blood count occurs measures quotes the work of Friemann who found that experimentally produced leukopenia in animals could be eliminated or prevented by the administration of vitamin C. Carrié tried the effect of vitamin C on roentgen leukopenia and concluded that it had a favorable influence, particularly if administered throughout the course of irradiation. We have given 1,000 units of ascorbic acid two or three times a day to a number of the patients in the present series

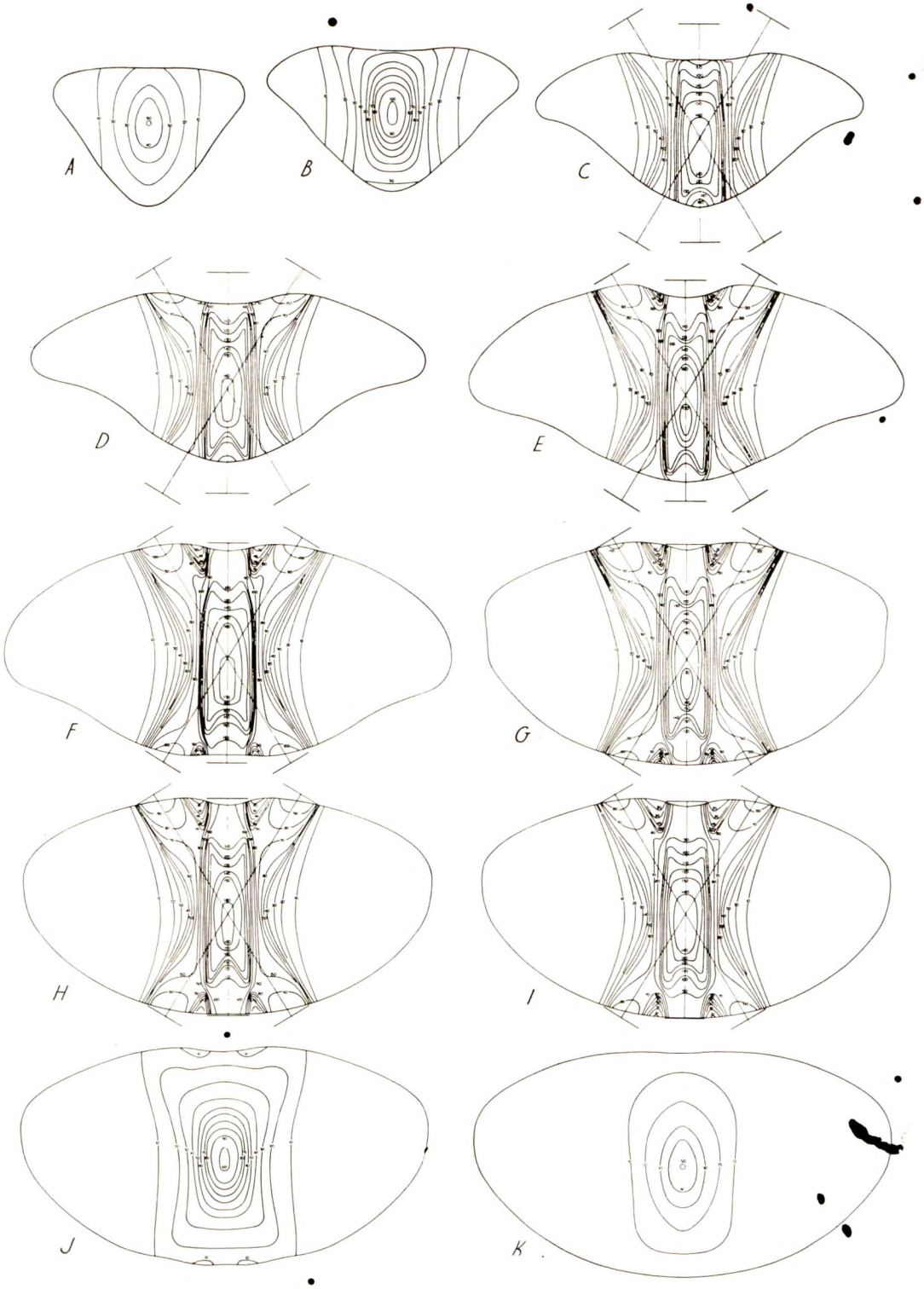


FIG. 2. Volume distribution in an average patient. Six fields 20×4 cm., 80 cm. focus-skin distance, 400 kv. (peak), 3.7 mm. Cu half-value layer. *A*, plane 12 cm. up from center; *B*, plane 11 cm. up from center; *C*, plane 10 cm. up from center; *D*, plane 8 cm. up from center; *E*, plane 5 cm. up from center; *F*, central plane; *G*, plane 5 cm. down from center; *H*, plane 8 cm. down from center; *I*, plane 10 cm. down from center; *J*, plane 11 cm. down from center; *K*, plane 12 cm. down from center.

and, though it is too soon to gain any clear impression of the result, we have been sufficiently encouraged to continue its trial. In certain cases the lymphocyte count after the usual initial fall has actually risen towards the end of treatment (see Fig. 1). Incidentally it has been found by Imler and Wammock[15] that irradiation nausea is sometimes controlled by the administration of large doses of vitamin B_1. There is certainly room for further work on the effects of a high vitamin diet for patients undergoing radiation therapy.

The effect of irradiation on the red blood cells is not so serious, but if the patient is already anemic large doses of iron are given or a blood transfusion carried out before treatment starts and repeated if necessary. Iron is also given to those women who have a history of idiopathic hypochromic anemia.

2. *Selection of the treatment fields.* The size, shape, number and positions of the treatment fields that are employed should be such that the best possible distribution of the radiation is obtained throughout the volume irradiated. The ideal distribution for tumors of the thoracic esophagus is one that results in the highest dose being delivered to a cylinder of tissue that includes the length of the esophagus involved by the growth, and at the same time delivers as small a dose as possible to the more sensitive of the normal structures in the thorax. As shown in the introduction, the length of esophagus involved may be considerable and is nearly always greater than that indicated by roentgen examination. To obtain an adequate tumor dose multiple fields must be used, and it is clear that long narrow fields will give the best distribution. Levitt[16] used five to eight fields measuring 16.5×5 cm. At first he spaced these fields widely around the chest wall but found that a diffuse fine fibrosis of the lungs with spasmodic cough and dyspnea resulted. To avoid this he either concentrated his fields round one side of the chest to limit the fibrosis to one lung or placed them all near the midline to avoid the lungs as far as possible. Roberts[28] used fields measuring 15×2.5 cm., sometimes employing as many as twenty-six of these strips arranged round the whole thorax.

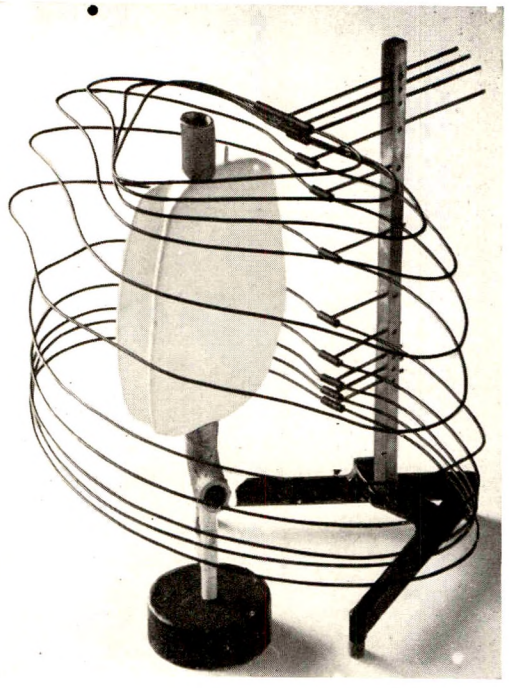


FIG. 3. Model of the average patient showing the relative positions of the cross sections in Figure 2, and the shape and position around the esophagus of the 140 per cent isodose surface.

The first few cases in the present series were treated with four fields, two in front and two behind, placed close to the midline and measuring 11×7 cm. It was found that this number of fields was too few as severe skin reactions were produced and too large a volume of tissue received the high dose. The fields were also too short in some cases for although local tumor regression occurred extension took place below the treatment field level. After discussions with other radiotherapists it was decided to use fields measuring 20×4 cm. ($d\frac{1}{2}=7.5$ cm.). A number of arrangements of fields of this size were tried and the distribution due to them in the central plane determined. From a study of these distribution charts the following scheme was adopted.

Six fields were employed arranged in three sets of directly opposing pairs: a

direct anteroposterior pair and two oblique pairs near the midline. The center of each anterior oblique field was placed 6 cm. from the center of the direct anterior field. The position of the posterior fields was such that the central ray of each directly opposing field pair passed through the tumor.

Mid-plane distribution charts are of value in helping to decide on an arrangement of fields but do not give the necessary information as to the distribution of the radiation in planes above and below this level. To decide finally on the best arrangement of fields, it is necessary to determine the complete three-dimensional or volume distribution on the lines of those already published by Honeyburne, Lamerton, Smithers and Mayneord.[14] While this is a comparatively simple matter for arrangements of circular fields it becomes more complicated when strip fields are used. The method adopted in obtaining the volume distribution due to these fields is described in Part II. The distributions were drawn in several parallel horizontal planes on cross sections obtained by taking an average of the dimensions of all the patients with cancer of the esophagus who had been treated during the past two years.

From a study of the three-dimensional distribution it was clear that the arrangement of six strip fields already described fulfilled most of the requirements laid down at the beginning of this section. It was found that the fall off in dose at the midpoint in planes above and below the center was of little consequence until a level just short of the length of the fields was reached. This is due to the fact that the isodose curves for each field are remarkably flat over the greater part of their length (see Fig. 17). This again is partly due to the high voltage (400 kv.) and also to the use of a long focal skin distance (80 cm.) which

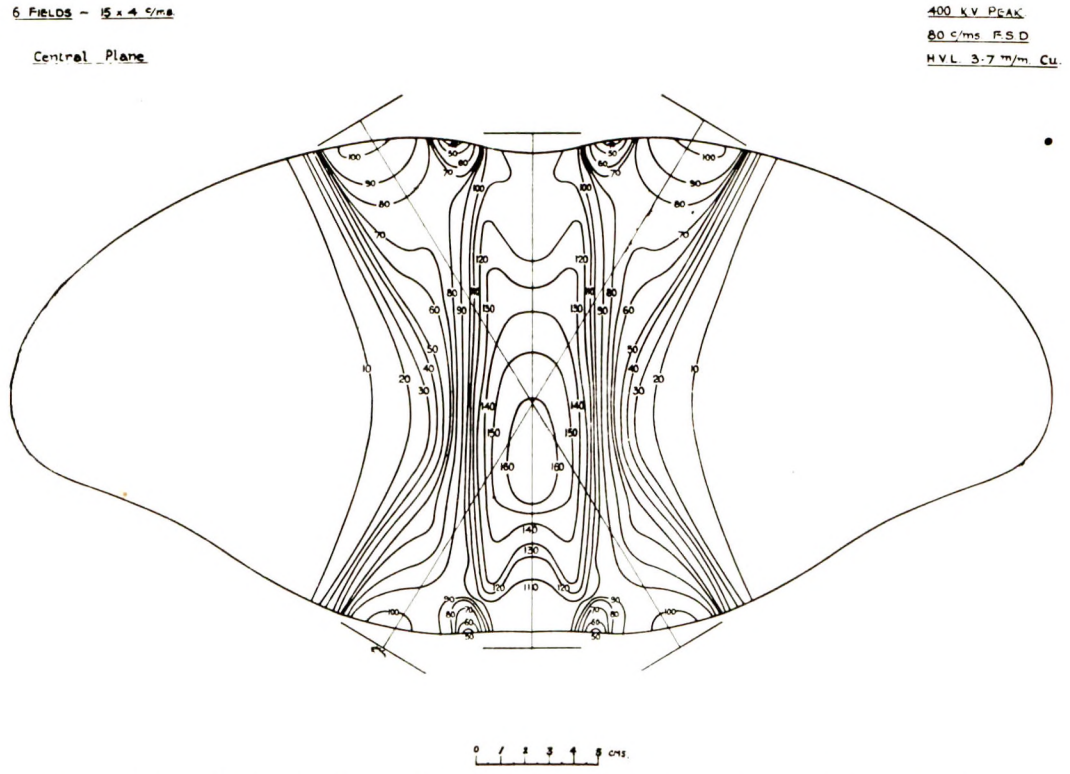


FIG. 4. Central plane distribution for conditions similar to those shown in central plane Figure 2, with the exception that the length of the fields is reduced from 20 cm. to 15 cm.

ods already described by Mayneord.[23] It is found that a 20×4 cm. field (400 kv., peak, 80 cm. focus-skin distance, 3.7 mm. Cu half-value layer) contributes approxi-

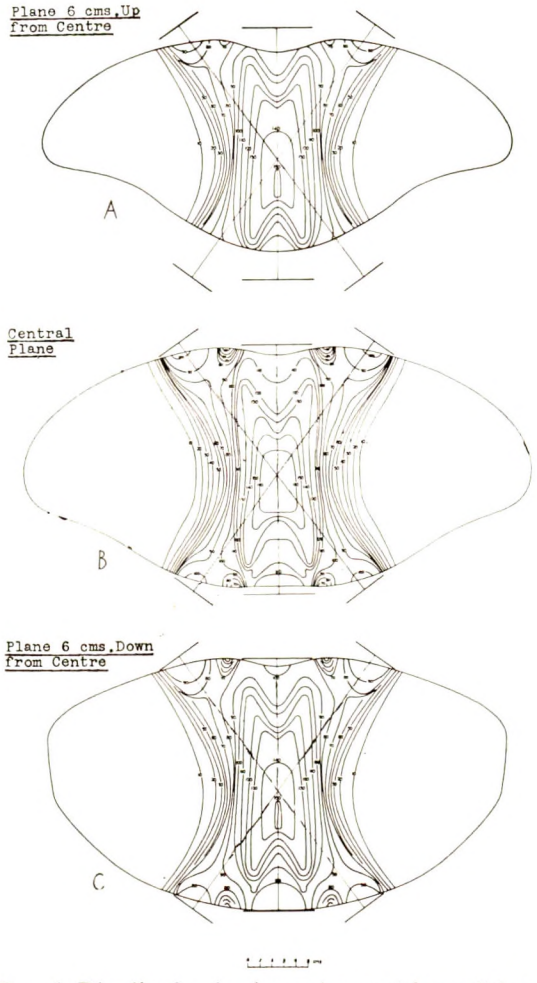


FIG. 6. Distribution in three planes with conditions similar to those shown in Figure 5, but with center of the anterior oblique fields 7 cm. instead of 6 cm. from the midline.

Six fields, two 15×6 cm., four 15×4 cm., 400 kv. (peak), 80 cm. focus-skin distance, 3.7 mm. Cu half-value layer. *A*, plane 6 cm. up from center; *B*, central plane; *C*, plane 6 cm. down from center.

mately 1,100 gram-roentgens per roentgen on the surface, a 15×6 cm. field 1,310 and a 15×4 cm. field only 770 gm-r each for total absorption. The six 20×4 cm. fields therefore give in all 6,600 gm-r per roentgen as opposed to 5,700 gm-r for the four 15×4 cm. plus two 15×6 cm. fields. In the "average patient" a minimum tumor dose of 6,000 r with the 20×4 cm. fields gives an "integral dose" of 28 megagram-roentgens, and with the 15×4 and 15×6 cm. fields 24 megagram-roentgens.

3. *Localization, fixation and beam direction.* The first step when the diagnosis is confirmed and the patient well enough for treatment is to localize the tumor. For this purpose we have adopted the method described by Roberts.[28] The tumor is localized by aligning it between two points on the surface in several planes using the fluoroscopic screen. The tumor is located by barium in the esophagus and the skin marked by a lead cross on one side of the chest and a lead ring on the other. The anteroposterior positions are marked first, the anterior lead ring is then moved 7 cm. to one side and the position for the corresponding posterior oblique field found, and then 7 cm. to the other side and the process repeated. Two details are of importance: first, the beam of roentgen rays must be horizontal, and second, the shutter must be closed down to a small aperture so that only the narrow central beam is used and distortion avoided. The six points are then marked on the skin. The disadvantage of skin markings is that their position relative to the tumor may change with position of the patient. In the present case this is particularly likely to occur when marks are placed on the skin over the vertebral borders of the scapulae. It is therefore important to screen the patient in that position in which he will be treated, preferably on the treatment couch itself. As the barium outlines the upper limit of the obstruction it is a point towards the upper end of the tumor that is localized. The fields are therefore applied so that one-third of their length extends above this level and two-thirds below. The points of entrance and exit of the central ray of each beam falls 2.5 cm. below the skin marks. An attempt is made to outline the lower limit of the tumor (Fig. 10) but this is not regarded as giving a very accurate indication of its extent.

have been adopted for this purpose. It was at once obvious that the length of the fields could be reduced without loss of efficiency in irradiating the primary tumor and with a gain in so far as the total energy absorption in the patient, the "integral dose," would be less. The volume distribution also showed that instead of the desired cylinder of high dosage around the tumor this volume was seriously flattened from side to side; in other words, the dose fell off rapidly on either side of the mid-point of the tumor (Fig. 2). Figure 3 shows the relative positions of the cross sections in Figure 2, and the shape and position around the esophagus of the 140 per cent isodose surface.

In order to correct these points and yet not increase the dose to the lungs the distributions due to new arrangements and sizes of field were determined. First the length was reduced to 15 cm. but the arrangements otherwise preserved (Fig. 4). Then the width of the two central fields was increased to 6 cm. to broaden the central high dose region (Fig. 5). Finally the centers of the two anterior oblique fields were moved out to a position 7 cm. from the midline on either side (Fig. 6). A study of these distribution charts shows the reasons for these steps and the advantages of the final arrangement selected.

The arrangement of fields now adopted, therefore, is as follows: six fields in three directly opposing pairs; an anteroposterior pair measuring 15×6 cm. each ($d\frac{1}{2}$=7.9 cm.) and two oblique pairs measuring 15×4 cm. each ($d\frac{1}{2}$=7.1 cm.); fields so arranged that the center of each anterior oblique field is 7.0 cm. from the midline and the central rays from all six fields meet at the center of the tumor.

The total energy absorption in the different techniques may be calculated by meth-

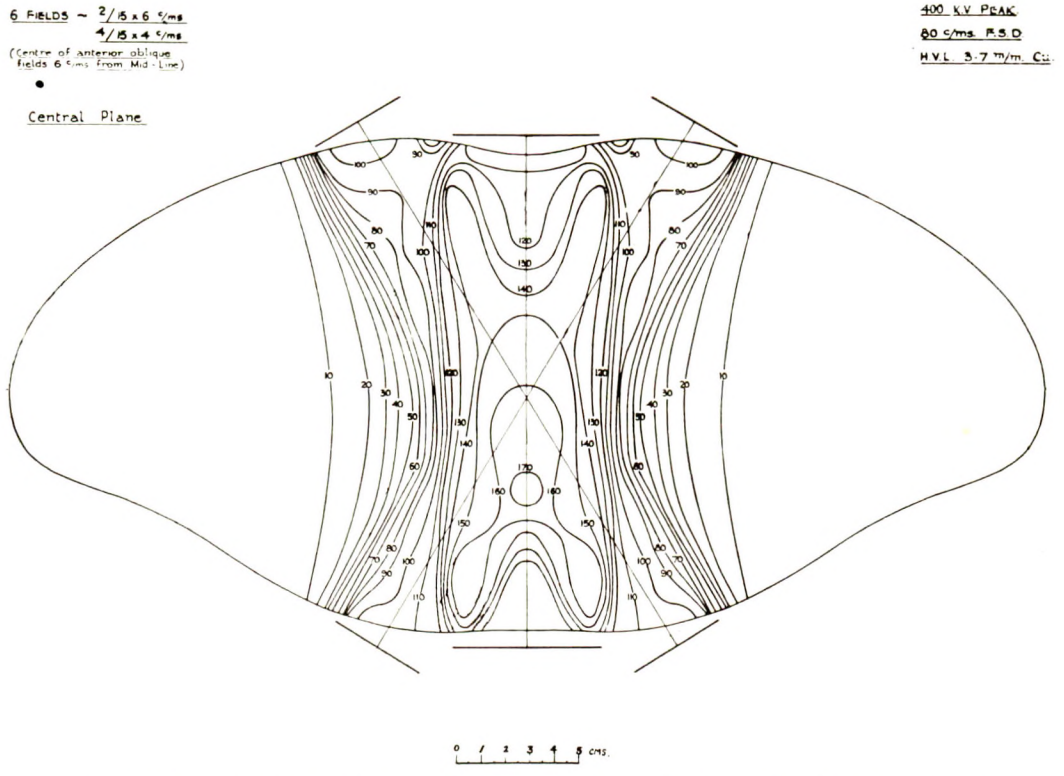


FIG. 5. Central plane distribution as in Figure 4, but with the width of the two central fields increased from 4 cm. to 6 cm.

down. If the patient is to be treated sitting up he must be fixed rigidly and yet supported in comfort. I have designed a roentgen therapy couch intended for use with patients having treatment to any part of the body. It is a modification of the "Panapoise" treatment table made by the Medical Supply Association. When the thorax is to be irradiated, axillary crutch supports and a webbing band are attached on either side and can be adjusted inde-

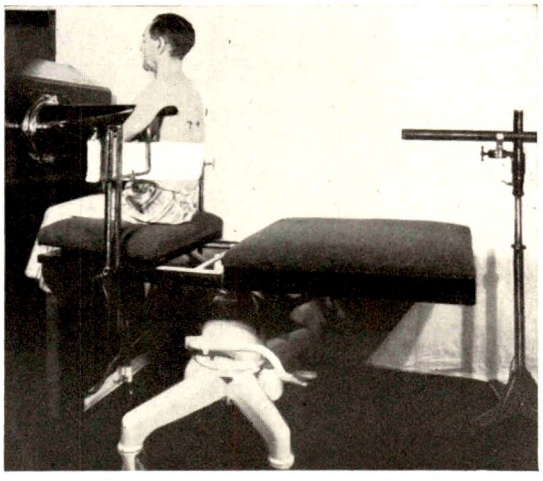


FIG. 8. Patient in position for treatment to the central anterior field, showing collineator and treatment couch.

pendently (Fig. 8). The axillary supports prevent lateral movement and a slight tilt of the seat prevents the patient slipping forwards. The webbing band passes round the patient above or below the skin marks and gives added support without interfering with free access to the whole thorax.

The accurate direction of the roentgen-ray beam is realized by the use of Mayneord's collineator.[21] When the patient is placed in position (Fig. 8) so that the hole in the center of the applicator falls 2.5 cm. below one skin mark and is then rotated until the beam of light from the collineator falls 2.5 cm. below the opposing mark, the conditions that pertained when the marks were fixed at screen examination are reproduced. The collineator lamp is operated by a switch in the control room so that it can be turned on frequently during treatment to see that the position has been maintained.

4. *Scheme of irradiation.* It is not possible to go through the lengthy process of determining the complete volume distribution of the radiation in every case. The main function of volume distributions is to determine the best standard arrangement of fields for a particular group of cases. Having decided this, it is then only necessary to determine the maximum and minimum tumor dose as accurately as possible for each case. For this purpose the cross-section diagram already referred to is used. The central plane isodose curves (Fig. 21) are placed in position on this chart for each field and the dose at the point of intersection of the central rays calculated. This represents the maximum tumor dose. It is not possible to determine the minimum tumor dose with the same degree of accuracy as the exact extent of the tumor is not known. From the volume distribution charts it can be seen that the central high dose region extends along the length of the esophagus sufficiently to include all probable local spread. The dose falls off laterally on either side of the central point more rapidly than it does in an anteroposterior direction so that the minimum tumor dose will occur in this region. We have selected an arbitrary point situated 2 cm. laterally from the tumor center and the dose is determined at this point also in every case. This dose is stated as the minimum tumor dose in the present series. It indicates that the dose to the tumor is greater than this at every point provided that the tumor is not more than 4 cm. broad at its center and falls within the isodose surface receiving this dose in the planes above and below the central plane. We believe this to be an adequate representation of the minimum tumor dose in the great majority of cases and to represent an under-statement in some instances.

A treatment is given to all six fields each day. All fields are irradiated daily so that not only is an even total tumor dose given but also an even daily tumor dose. The

A cross-section drawing of the patient's chest is then made. Metal strips molded around the chest do not give a sufficiently accurate outline so a special apparatus was designed by Professor W. V. Mayneord for this purpose. This apparatus (Fig. 7) is similar to one previously described by Martin.[20] It consists of a rectangular metal frame hinged at the center of one short side and joined by a catch at the center of the opposite side. This frame carries a number of small metal rods which pass through it horizontally on all four sides. The frame can be opened, placed around the patient at the required level, and closed again. The metal rods are then pushed inwards until they just touch the skin around the whole chest surface. The catch is released and the frame opened and removed. The frame is now closed again and placed over a drawing board so that the outline of the chest at that level can be transferred to paper.

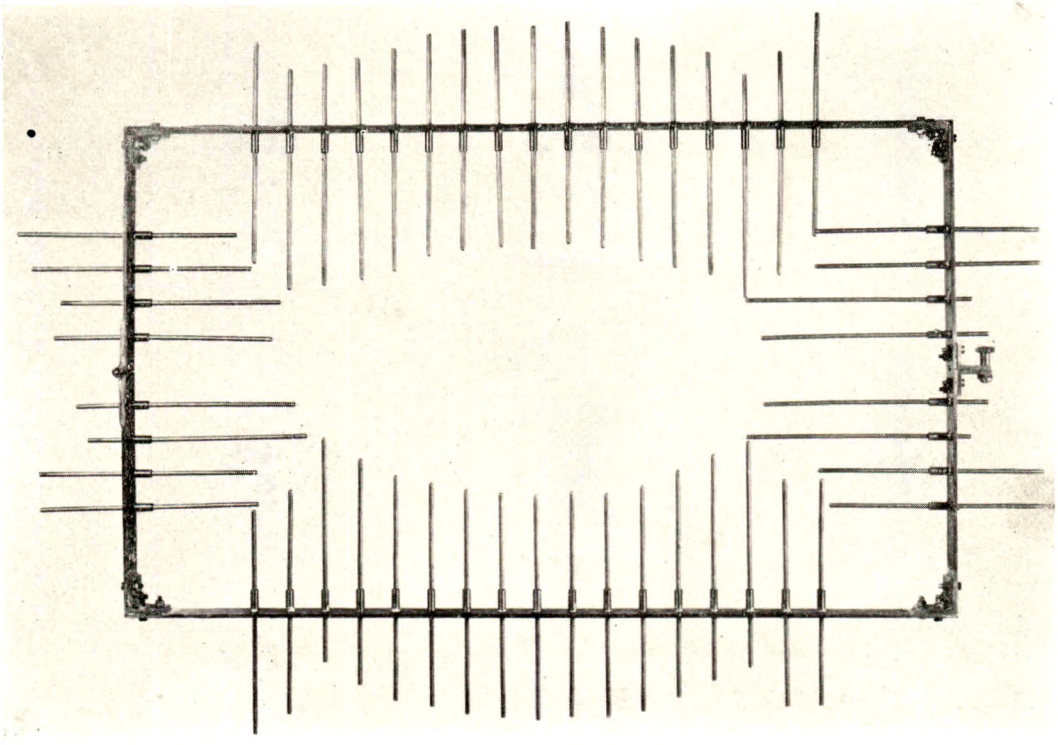


Fig. 7. Apparatus used to obtain a cross section drawing of the chest at any level.

The position of the skin marks are placed on the cross-section drawing, and joined by lines representing the central axes of the beams of radiation. If the procedure has been carried out accurately, the three lines should all intersect at one point, the center of the tumor. This is the first check on accuracy. The distance between the points of entrance and exit of each beam is measured on the patient with calipers and checked on the drawing. A lateral roentgenogram of the chest is taken with barium in the esophagus at a distance of 6 feet and the position of the tumor in an anteroposterior direction found. This is again checked with the position of intersection of the lines on the drawing. This cross-section is then used to determine the tumor dose due to a combination of the six fields selected in this particular patient.

In order to ensure accurate beam direction the patient is treated in the sitting position. Slight degrees of rotation of the patient may pass unnoticed if he is lying

treatment is given each week day over a period of five to seven weeks. Daily fractional treatment over a period of approximately six weeks has been adopted in the present state of our knowledge as being that which offers the best chance of success. It is to be hoped that we may later arrive at a stage when we can select the appropriate spacing of our fractional irradiation according to the histological structure of the tumor. Thus we may hope to obtain the maximum tumor effect in every case. Daily irradiation has been adopted for the present with the dose given each day remaining constant or rising towards the end of treatment in the case of the more highly differentiated tumors.

The majority of the cases in the present series have been treated with a Victor (400 kv., peak) "Maximar." The filtration was 0.22 mm. Sn with 1.7 mm. Al added, the inherent filtration being equivalent to 2.0 mm. Cu, the half-value layer of the radiation being 3.7 mm. Cu. The focal skin distance was 80 cm. The dosage rate on the skin surface was about 10 r/min. and at the tumor center about 3 r/min. The daily dose to each field is so arranged that if treatment is uninterrupted the tumor dose will be between 6,000 and 7,000 r in six weeks. In the average case this means a daily dose per field of 100 r. Any air spaces between portions of the applicator and the chest wall are filled in with rice bags. Each treatment is plotted on a graph showing the variation of dose with time and plotted daily (see upper part Fig. 1). These graphs show the maximum and minimum tumor dose given and the shape of the curve of dose with time.

5. *Care of the patient after treatment.* Within a week or two of the cessation of treatment the barium filled esophagus is examined on the screen and a roentgenogram taken for comparison with the original and subsequent films. This examination is repeated six to eight weeks later. By this time the reaction has subsided in most cases and an esophagoscopy may be performed. In a successful case the first esophagoscopy following treatment may show some edema and small areas of flat ulceration but later examinations show only a thin white scar. Thick scars forming obstruction are not seen but some general contraction may take place. If there is the least tendency to this fibrotic constriction careful and repeated dilatation should be undertaken. The higher the tumor in the esophagus, the more frequently does dilatation appear to be required. An esophagoscopy is performed every few months or at any time that untoward symptoms appear. A portion of any suspicious area may be taken for biopsy at any of these examinations. A roentgen examination is carried out from time to time as a check and the patients are weighed regularly.

II. Postcricoid Tumors of the Pharynx and Tumors of the Cervical Esophagus.

The points referred to in the description of the treatment of tumors of the thoracic esophagus apply also to tumors of the upper and lower limits of the organ with the exception of the arrangement of the fields. Tumors of the upper limit of the esophagus lie nearer the anterior than the posterior surface at a level where the thorax is flattened anteroposteriorly. Tumors in this region do not tend to spread so rapidly or so extensively along the length of the esophagus as do those arising at a lower level. It is not, therefore, necessary to use as many as six fields or to employ long strips. Four small strip fields 10×6 cm. may be used on either side of the midline, two in front and two behind, the posterior fields being further from the midline than the anterior, as the tumor is nearer the front than the back. This gives a good distribution so far as the primary tumor is concerned but owing to the curvature of the base of the neck it is difficult to set these fields accurately or closely in contact with the skin. For this reason and also because it includes the lymph nodes at the base of the neck we have adopted the following arrangement.

A directly opposing anteroposterior pair of fields measuring 10×6 cm. is arranged

so that the two central rays pass through the tumor. Two 7 cm. diameter circular fields are placed on either side of the neck in the same anteroposterior plane as the tumor but angled downwards and inwards. The central rays of these two beams meet at a point just below the tumor so that the region of high dosage due to them falls at the tumor level. The distribution is worked out for each individual case as they vary widely. For this purpose a plaster mask is made of the patient's neck and shoulder regions and the dose from the four fields determined on an improved form of Mayneord's "dose finder."[22] The position of the fields is finally fixed on the mask and the angle on the tube adjusted so as to reproduce this position on the patient. The anteroposterior fields are aligned with the collineator as before.

Tumors of the Abdominal Esophagus and of the Cardiac End of the Stomach Involving the Esophagus.

As already stated, the main difficulty in giving an adequate dose of roentgen rays to a carcinoma of the esophagus is the constitutional effects produced, especially the leukopenia. With tumors in the region of the cardia this difficulty is increased as both the liver and spleen will be irradiated. As a result, an adequate tumor dose has seldom been given in the past and the results have been so disappointing that the method has practically been abandoned for tumors in this situation. Regelsberger[27] succeeded in getting relief of symptoms, gain in weight and disappearance of occult blood in the stools in 60 per cent of cases of inoperable gastric cancer. Of 35 patients treated by him 6 survived more than a year and 2 of them were still alive three years after treatment at the time of his report. Merritt[24] treated 13 patients and 3 were alive, well, and symptom free at the time of his report. Patients with tumors in this region are sometimes treated by the implantation of radon seeds with marked tumor regression and relief of symptoms. There is no doubt that many of these tumors are moderately radiosensitive. We have therefore recently attempted to treat with roentgen rays a few patients with gastric carcinomata situated at the cardia and involving the esophagus.

Tumors at the lower limit of the esophagus are to the left of the midline and form a more rounded tumor mass than those in the thoracic esophagus. The arrangement of fields used has either been four fields 10×10 cm. in two directly opposing pairs or more recently six fields measuring 10×6 cm. in three pairs. The treatment was carried out in the same way as for the thoracic tumors and, although it was not often possible to give so high a dose, a minimum tumor dose of 5,000 r in six weeks was reached in several cases.

Account of the Cases of Carcinoma of the Esophagus Seen at the Royal Cancer Hospital from 1936 to 1939.

This report is concerned chiefly with 66 patients referred to the roentgen department but in order to indicate how far these represent a selected group the hospital records were examined and a further 49 cases found. Table VI shows the distribution of these cases according to site of the tumor.

Eight of the 10 cases of postcricoid carcinoma not referred to the roentgen department received teleradium treatment. Ten of the remaining patients not referred for roentgen treatment were treated with a radium bougie and 9 with radon seeds, 3 were operated on and 19 had no treatment or merely a palliative gastrostomy. Of the 66 patients referred to the roentgen department treatment was attempted in 54 and completed in 40. The distribution of these patients according to the site of the tumor and the immediate response to treatment is given in Table VII.

Only 4 patients who completed their treatment noticed no improvement; all had tumors in the middle of the esophagus. Three patients received partial relief of symptoms without completing their treatment, 1 had a tumor in the middle third and 2 in the lower third of the esophagus.

TABLE VI

DISTRIBUTION OF ALL 1936–1939 CASES ACCORDING TO THE SITE OF THE TUMOR

	Postcricoid Tumors of Pharynx	Tumors of Esophagus			Tumors of Stomach Involving the Esophagus	Total
		Upper Third	Middle Third	Lower Third		
Not referred to roentgen department	10	4	16	6	13	49
Referred to roentgen department	4	8	34	9	11	66
Total	14	12	50	15	24	115
Male	2	10	36	12	21	81
Female	12	2	14	3	3	34

Three patients had already received some roentgen treatment elsewhere, 1 was too ill to treat at all, 1 had two weeks' treatment and died one week later, the third had only had a very small dose one month before and completed treatment with some relief of symptoms. No patient was said to have had a partial relief of symptoms unless his swallowing definitely improved and he gained weight. With the exception of cases of carcinoma of the stomach no patient was considered to have completed treatment who did not receive a minimum tumor dose of at least 5,000 r. For those who completed treatment the shortest treatment period was thirty-five days and the longest 118 days, the great majority were treated in from forty to fifty days.

Of the 12 cases that were not treated, 3 were lost sight of, the remaining 9 lived an average of 2.6 months. Of the 14 that did not complete treatment, 2 were lost sight of, the remainder lived an average of 2.5 months.

Results of Treatment.

1. *Postcricoid tumors.* The majority of cases of postcricoid carcinoma were referred to the radium department and treated with teleradium. Of the 4 cases treated by roentgen rays 2 already had cervical lymph node involvement and 1 had started teleradium treatment when war was declared and was then transferred to the roentgen department. This last patient had nearly two-thirds of her treatment by teleradium;

TABLE VII

CASES REFERRED FOR ROENTGEN TREATMENT 1936–1939

	Postcricoid Tumors of Pharynx	Tumors of Esophagus			Tumors of Stomach Involving the Esophagus	Total
		Upper Third	Middle Third	Lower Third		
Total	4	8	34	9	11	66
Male	0	6	25	8	11	50
Female	4	2	9	1	0	16
Treated	4	8	28	8	6	54
Completed treatment	3	5	21	6	5	40
Average duration of symptoms before admission in months	4.2	4.3	4.2	3.5	8.5	
Symptoms not relieved	1	3	9	2	0	15
Symptoms partially relieved	1	1	12	5	4	23
Symptom free	2	4	7	1	2	16

TABLE VIII

RESULTS OF TREATMENT IN CASES OF CARCINOMA OF THE STOMACH INVOLVING THE ESOPHAGUS

Age	Length of Symptoms before Admission in Months	Time between Treatment and Death in Months	Treatment Given (Tumor dose)	Subsequent History
60	9	6	2,000 r in 23 days	Died at home
60	12	8	5,500–5,100 r in 40 days	Marked improvement followed by return of symptoms increasing weakness and death
64	4	4	5,800–5,300 r in 39 days	Slight improvement in symptoms. Died with metastases
69	2	3	5,800–4,900 r in 46 days	Slight improvement in symptoms. Died
50	12	Alive	5,300–4,700 r in 44 days	Alive and symptom free 1 year and 2 months after treatment
51	12	Alive	5,500–4,300 r in 47 days	Alive 1 year after treatment with some difficulty in swallowing solids

when last seen fifteen months after treatment she was symptom free with no sign of any recurrence. Of the 2 patients with cervical lymph node metastases 1 had to have a gastrostomy, failed to complete her treatment owing to weak condition and dyspnea, and has not been heard of since; the other completed treatment. In this patient the hard lymph nodes palpable on both sides of the neck subsided and swallowing was much improved; she was alive and well when last seen six months after treatment but had required occasional dilatation. The 1 patient with no palpable lymph nodes treated solely by roentgen irradiation was sent by Mr. R. Scott Stevenson and discussed by him at the Section of Laryngology of the Royal Society of Medicine previously.[30] It was not possible to obtain a piece of the tumor for biopsy to confirm the diagnosis histologically in this case. The patient aged seventy-six lived for seventeen months free from symptoms and died of intercurrent disease without any sign of recurrence.

2. *Tumors of the stomach involving the*

TABLE IX

RESULTS OF ROENTGEN TREATMENT OF 32 PATIENTS WITH CARCINOMA OF THE ESOPHAGUS

	Upper Third	Middle Third	Lower Third	Total
No. of cases	5	21	6	32
No. dead	2	19	5	26
Average time from onset of symptoms to death in months	9	13.2	13.8	12.9
Average time from treatment to death in months	5.5	8.5	12.5	8.5
No. alive	3	2	1	6

TABLE X

DETAILS OF THE 6 PATIENTS STILL LIVING FOLLOWING ROENTGEN TREATMENT FOR CARCINOMA OF THE ESOPHAGUS

No.	Sex	Age at Beginning of Treatment	Pathological Report	Position of Tumor	Tumor Dose	Survival Period from Onset of Symptoms Till Last Seen, in Months	Survival Period from Treatment Till Last Seen, in Months	Condition of Patient When Last Seen
1	M	56	Grade 1 fungating squamous cell carcinoma	Upper third	7,200 r in 118 days	50	48	Symptom free
2	F	64	None	Middle third	6,900–6,300 r in 39 days	37	32	Has attacks of dysphagia at times. Was never dilated
3	M	64	Grade 4 squamous cell carcinoma (basal cell type)	Lower third	6,900–6,500 r in 41 days	32	27	No difficulty in swallowing. Admitted to another hospital and getting weaker
4	M	61	Grade 2 intra-epithelial squamous cell carcinoma	Upper third	6,400–5,800 r in 39 days	32	29	Symptom free
5	F	75	Grade 2 squamous cell carcinoma	Upper third	5,500–5,200 r in 30 days	16	13	Not seen since April, 1940. Was then symptom free and had no sign of growth on esophagoscopy
6	F	74	Grade 2 squamous cell carcinoma	Middle third	6,400–5,300 r in 43 days	15	14	Symptom free

Average length of symptoms before treatment 3.2 months. All showed more or less widespread invasion of submucous tissue. Submucous lymphatic invasion seen in Cases 4 and 6. Cases 1, 4 and 6 have had a recent esophagoscopy performed without any sign of a tumor being observed.

esophagus. Six patients were treated in this group, 1 failed to complete treatment, 1 is still alive but has had a return of symptoms, and 1 is alive and symptom free. This last patient showed no sign of growth when given a barium meal or esophagoscoped. The results of treatment in this group are shown in Table VIII.

3. *Tumors of the esophagus*. Fifty-one patients with carcinoma of the esophagus were referred for roentgen treatment, 44 were treated and 32 completed their treat-

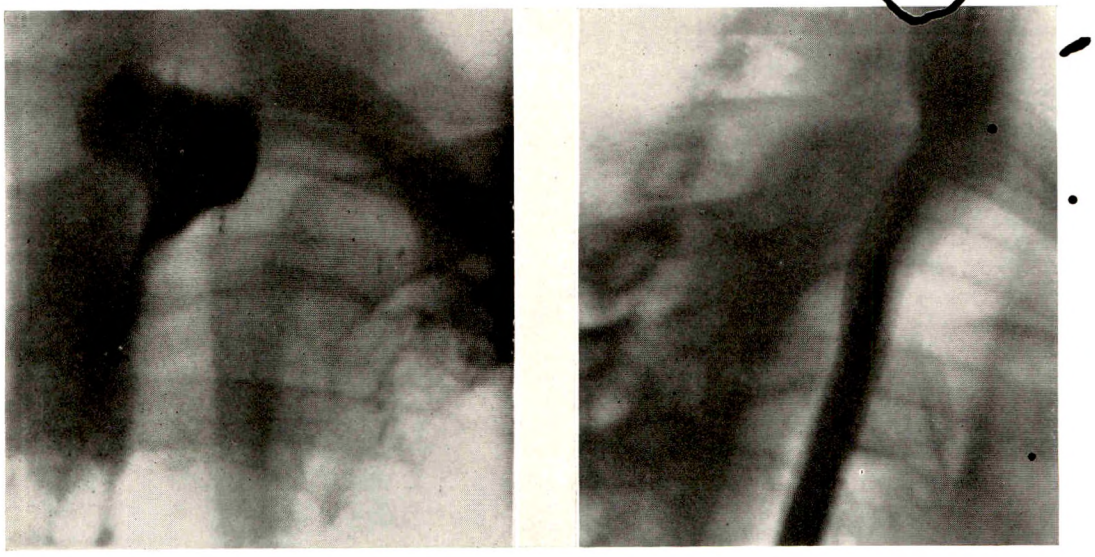


FIG. 9. Carcinoma of the upper third of the esophagus before treatment and six months after treatment (Case 4, Table x).

ment. These 32 were divided into 5 with the main part of the tumor in the upper third of the esophagus, 21 in the middle third, and 6 in the lower third. The results of treatment are shown in Tables IX and X.

Eight of the patients who died lived a year or more after treatment and 1 lived more than two years. Three who died with metastases were known to have had no return of symptoms, and 4 others who were never symptom free could swallow semi-solids to time of death; in 2 of these an

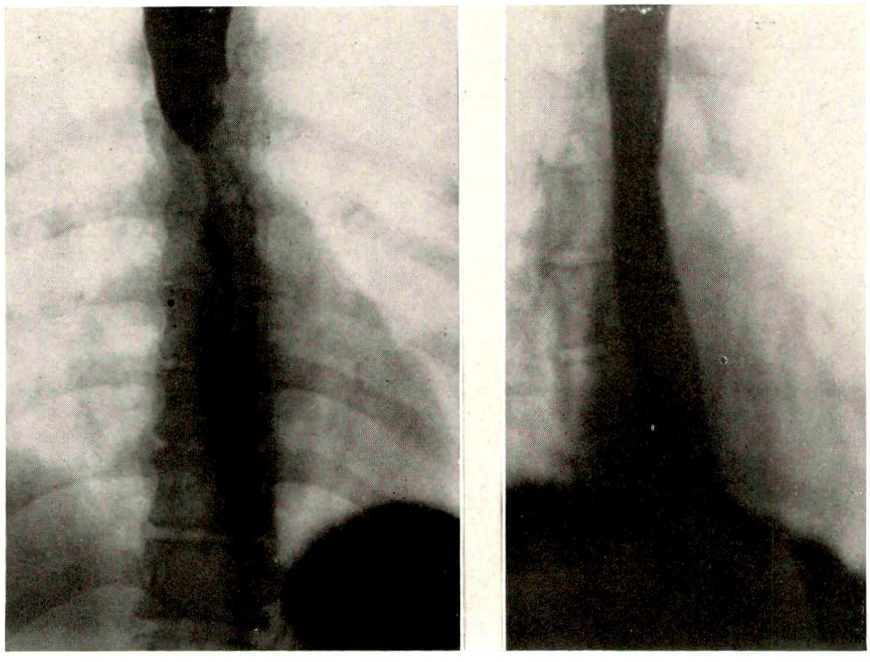


FIG. 10. Carcinoma of the middle third of the esophagus before and after treatment. Patient swallowed normally until she died one year and two months later with metastases.

esophagoscopy performed shortly before death showed no evidence of local growth. Of the 25 patients in this group who died, 10 were known to have developed metastases, 3 were known to have died following perforation, and in 13 the only information received was the date of death.

Figures 9-12 show roentgenograms of some of these patients before and after treatment. Figure 13 shows the roentgenograms and postmortem specimen of another case of considerable interest. Despite the length of esophagus irradiated, extension took place at the level of the upper and lower limits of the treatment fields.

From these tables it can be seen that 1 patient is alive and well four years after treatment. This patient was treated by Dr. S. B. Nowell who was at that time working in the roentgen department of the Royal Cancer Hospital. Three other patients are alive and well more than two years after treatment. One has gained as much as two stone in weight.

Figure 14 shows the effect of treatment

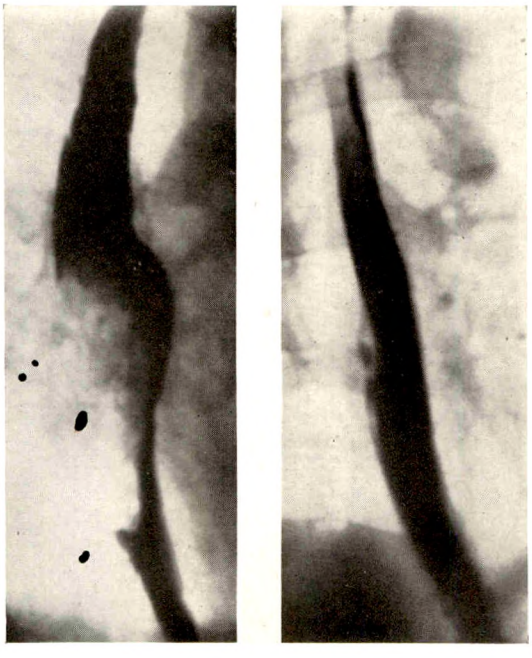


FIG. 11. Carcinoma of the middle third of the esophagus before treatment and three months after treatment (1940 case).

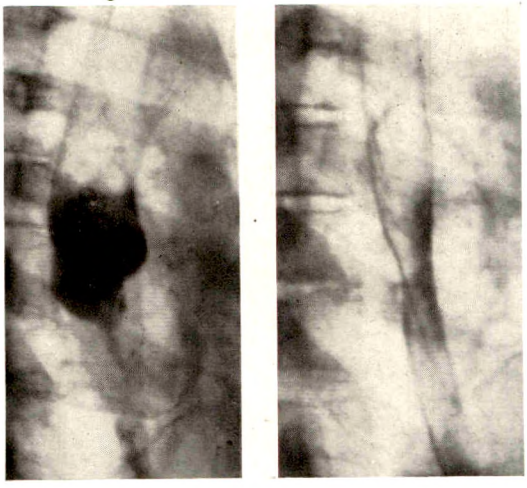


FIG. 12. Carcinoma of the lower third of the esophagus before treatment and eight months after treatment (Case 3, Table x).

in the whole group of 32 patients. Of 44 patients treated 30 obtained some relief of symptoms and 11 complete relief. Of 15 patients treated during the first half of 1940, 7 have obtained some relief and 7 are symptom free.

There has been no case which has developed fibrosis of the lungs. Skin reactions, with the exception of one or two of the early cases, have been mild erythemas only. There has been no sign of cardiac damage in any of the patients treated. In only 1 case was there any damage to normal tissues which might be attributed to the effect of the roentgen irradiation. This patient (Case 4 in Table x) developed a lesion in his spinal cord one year and three months after treatment. He was examined by Dr. C. Worster-Drought who made the following commentary: "The neurological syndrome found is one of Brown-Séquard syndrome and results from a unilateral lesion in the left side of the spinal cord at the level of the third and fourth thoracic segment. The lesion is intramedullary and there is no block in the spinal subarachnoid canal. The lesion can only be one of intramedullary gliosis, i.e., spinal gliosis which may or may not be an early stage of syringomyelia." The cerebrospinal fluid was normal and the Wassermann reaction negative. The level

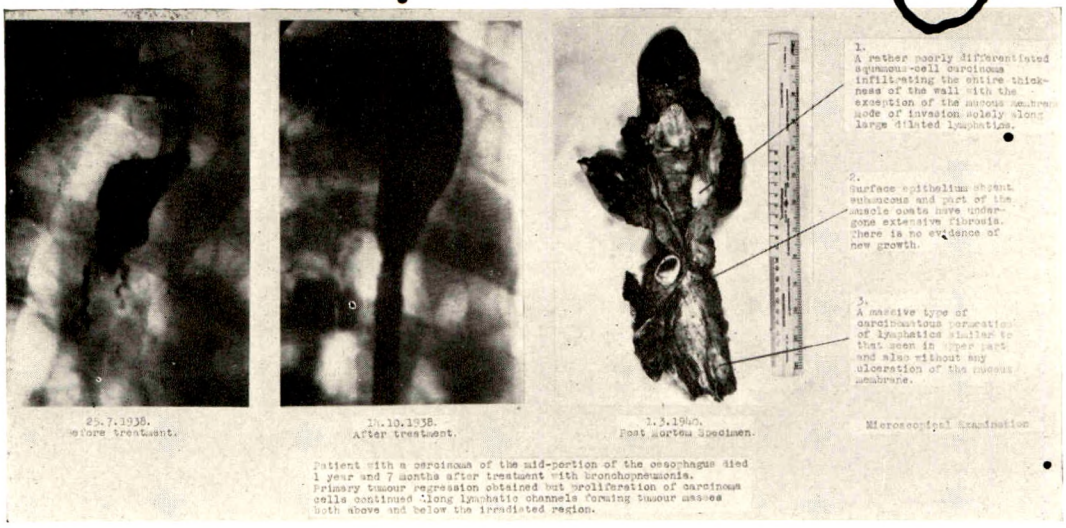


FIG. 13. Carcinoma of the middle third of the esophagus showing eradication of tumor at the site of obstruction and submucous extension of the growth above and below the level of the treatment fields.

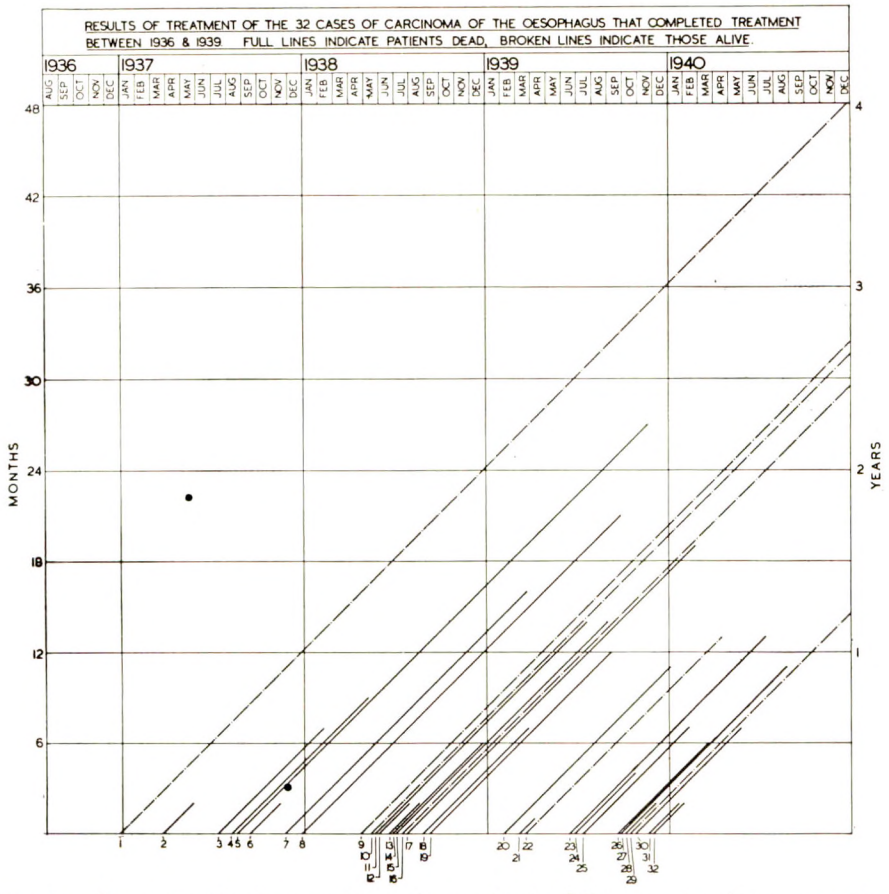


FIG. 14. Results of treatment in those patients who received a full tumor dose between 1936 and 1939.

of the lesion was in the previously irradiated region and it was calculated that the spinal cord at this point received a dose of 5,800 r in thirty-nine days.

The final modifications of the treatment techniques described were put into full operation at the beginning of 1940. Table XI gives the details of the 20 patients in this group who have been seen during the first six months of the year. It is too soon to comment on anything but the immediate symptomatic response in these cases. The fact that only one failed to complete treatment and that this was the only one who obtained no relief of symptoms is an encouraging sign. This patient died in one month with metastases in the liver. Of the 5 patients who were not treated, 3 are known to have died in less than one month and the other 2 had metastases when first seen. In 1 case there was a large fixed mass of cervical lymph nodes and in the other multiple secondary deposits were visible in a chest roentgenogram.

This paper was completed in December, 1940, but owing to war conditions was not despatched for publication until April, 1941. At the time of correcting the proofs (March, 1943) Cases 1, 2 and 4 in Table X were still alive and symptom free at six years and three months, five years, and four years and eight months from treatment. Case 3 died two years and four months after treatment with metastasis but no sign of local recurrence. Case 5 died eighteen months after treatment from intercurrent disease without any return of symptoms. Case 6 died eighteen months after treatment with metastasis and return of dysphagia.

TABLE XI

CASES REFERRED FOR ROENTGEN TREATMENT DURING THE FIRST SIX MONTHS OF 1940

	Postcricoid Tumors of the Pharynx	Tumors of the Esophagus			Tumors of the Stomach Involving the Esophagus	Total
		Upper third	Middle third	Lower third		
Total	3	2	5	5	5	20
Male	0	2	5	4	4	15
Female	3	0	0	1	1	5
Treated	2	2	3	4	4	15
Completed treatment	2	2	3	4	3	14
Average duration of symptoms before admission in months	8	2	2.8	4.4	6.4	
No relief of symptoms	0	0	0	0	1	1
Symptoms partially relieved	2	0	1	4	0	7
Symptom free	0	2	2	0	3	7

PART II

AN ACCOUNT OF THE PHYSICAL MEASUREMENT OF THE VOLUME ROENTGEN-RAY DOSAGE DISTRIBUTION DUE TO ELONGATED FIELDS

By J. R. Clarkson and J. A. Strong

Introduction. The study of the distribution of dosage throughout the irradiated volume in certain selected methods of roentgen or gamma-ray therapy has lately been undertaken at the Royal Cancer Hospital (Free) and results have already been published.[14] The methods described are applicable to fields having an axis of symmetry and require that a three-dimensional isodose surface system may be constructed by rotation of the normal plane diagram about that axis. In the present case where the treatment is carried out by the use of elongated rectangular fields these methods

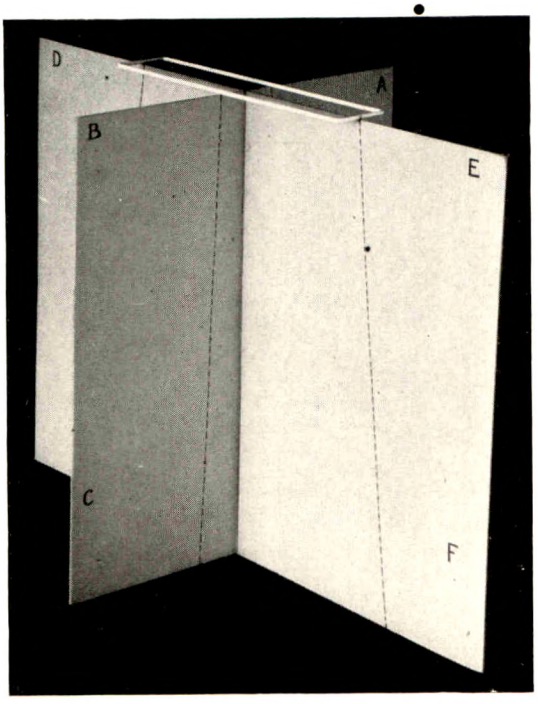


FIG. 15. Position of the reference planes with respect to the 20×4 cm. applicator.

are not applicable. The method of investigation adopted was to make dosage measurements throughout the whole volume irradiated by such a field and to construct dose contour diagrams in planes normal to the surface, afterwards combining the results for each of the six fields in the appropriate positions to obtain a diagram of the complete dose distribution at certain planes in the body.

In Figure 15, the outline of the applicator 20 cm. long and 4 cm. wide is represented by a rectangle lying on top of the cardboard sheets *ABC* and *DEF*. The dotted lines represent the geometrical limits of the irradiated volume in these planes. The plane *ABC* at right angles to the surface of the applicator and parallel to the shorter axis of the field is called the central plane. The plane *DEF* is called the longitudinal plane. Dose contours were constructed for the central plane and for planes parallel to it, but distant 5, 8, 10, 11 and 12 cm. from it on either side. The measurements of dosage were made in a water phantom of dimensions 42.5×42.5×110 cm.

Apparatus and Measurement Technique. The treatment of carcinoma of the esophagus is carried out at the Royal Cancer Hospital (Free) with a tube excited by 400 kv. pulsating tension, found with the filters used (0.22 mm. Sn+2 mm. Cu+1.7 mm. Al) to be equivalent to 350 kv. constant potential. The results described here were obtained in the physics department using this constant potential and filter. The half-value layer of the radiation was found to be 3.7 mm. Cu, identical with that of the radiation used in the treatment.

The cylindrical ionization chamber employed was of 5 mm. internal diameter and 5 mm. internal length made of "Aerion." This, and the measuring system have been previously described,[8] but certain modifications were introduced to permit of movement of the chamber in three directions. A further section of "Tombac" tubing was introduced into the evacuated conduit carrying the connection to the chamber electrode and also a fulcrum to provide a fixed point approximately 4 meters from the chamber about which the latter could move. The fulcrum consisted of a square aperture in a brass plate, allowing the lead to slide fairly freely but not permitting lateral or vertical movement at that point. As previously described, the lead was supported near its center in a block movable in two directions and lateral or vertical movement of the point of support could be read from vernier scales while longitudinal movement was read on a scale attached to the lead and moving past an edge on the support. With this arrangement when the point of support was moved laterally or vertically, the chamber moved in circular arcs about the fulcrum as center, while longitudinal movement by sliding the connecting lead was necessarily accompanied by a slight change in level except in the special case where the point of support was in the same horizontal line as the fulcrum. Before commencing measurements of depth dosage the rectangular coordinates of the

center of the chamber were determined for a range of positions of the three scales, using squared paper set accurately horizontally or vertically and wire pointers on the movable lead. By graphical interpolation the precise position of the chamber in the field was known for any setting of the scales. By the use of cross threads mounted on the limiting diaphragm of the beam and immediately above the surface position of the chamber in the phantom, and also a marker on the bottom of the water phantom, the tube focus, center of field at surface, and center of chamber were put accurately into vertical alignment. The field was limited to 20×4 cm. by an aperture in a lead diaphragm distant 55 cm. from the focus, the total focal distance to the water surface being 80 cm. The aperture size could be adjusted by sliding lead strips approximately 1 cm. thick. Having been set by calculation, the size was checked roentgenographically. The alignment was also periodically checked roentgenographically. In measuring depth doses on the central axis of the field, the longitudinal displacements which resulted as the chamber was lowered were corrected at each step. For other axes the chamber was allowed to move in circular arcs and the position at each setting found from the preliminary measurements of coordinates. The slight rise that accompanied a movement of the chamber on the surface—never more than 2 mm.—was invariably corrected so as to give true surface readings with half the chamber immersed.

Before commencing a set of readings it was confirmed by closing the aperture with lead and attempting a measurement of ionization in the surface position that the stray radiation recorded was negligible. During the early measurements it was found that after a time a serious natural leak developed between the charged outer wall of the chamber and the collecting electrode. This was ascribed to a condensation of moisture on the surface of the amber insulation when the chamber, which had been sealed in a warm and probably humid atmosphere, was lowered into the cold water of the phantom. For the rest of this work the phantom was filled with water a few degrees above atmospheric temperature. The leakage current was then entirely eliminated.

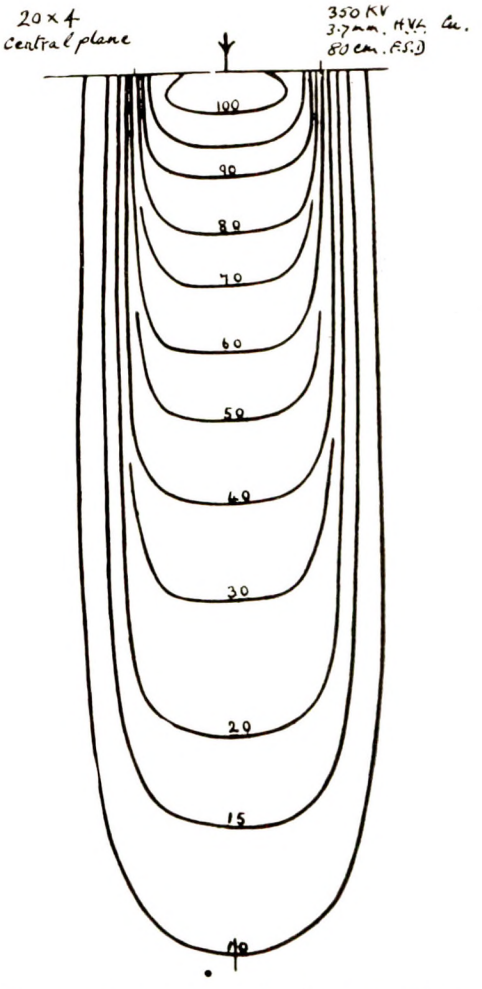


FIG. 16. Dose contours for the central plane.

To enable the constancy of output of the roentgen tube to be maintained a monitoring system was constructed. It consisted of a number of insulated parallel plates of thin aluminum, alternate plates being earthed or maintained at about 2,000 volts potential. This multi-plate chamber was mounted on the tube housing so that the beam passed through it, the relatively large ionization current being passed through a reflecting

galvanometer. In operation, constancy was checked by observation of the galvanometer deflection in preference to reliance on indications of a milliammeter and pre-reading kilovoltmeter.

Method of Constructing Dose Contour Diagrams. Dose contours were obtained for planes parallel to the central plane *ABC* (Fig. 15) and extending to positions outside the geometrical boundaries of the field. The dimensions of a patient and the positions of the fields in treatment were obtained by taking averages of all cases recently treated in the radiological department. The method adopted for the addition of percentage doses in any one plane within the "patient," although somewhat laborious, was thought to give greater accuracy than would have been obtained by estimation and addition using one dose contour diagram successively placed in the positions of the six irradiated fields. The contour diagram of a single field was first drawn on celluloid, and a tracing of it made on paper (Fig. 16). This and the original diagram were placed in the positions of the two central fields, i.e., 21 cm. between surfaces and with axes coincident, and a composite dose contour diagram compiled for these two fields, by drawing on another sheet of paper held firmly over them. The points of intersection of lines on the two original diagrams gave with certainty points on the lines of the composite diagram, and the points were supplemented where necessary by estimation. In the same way a pair of opposing oblique fields were combined and a tracing made for the other pair. By combining in turn the resulting diagrams, the four oblique fields were compounded and lastly the central fields were added (Fig. 2, central plane).

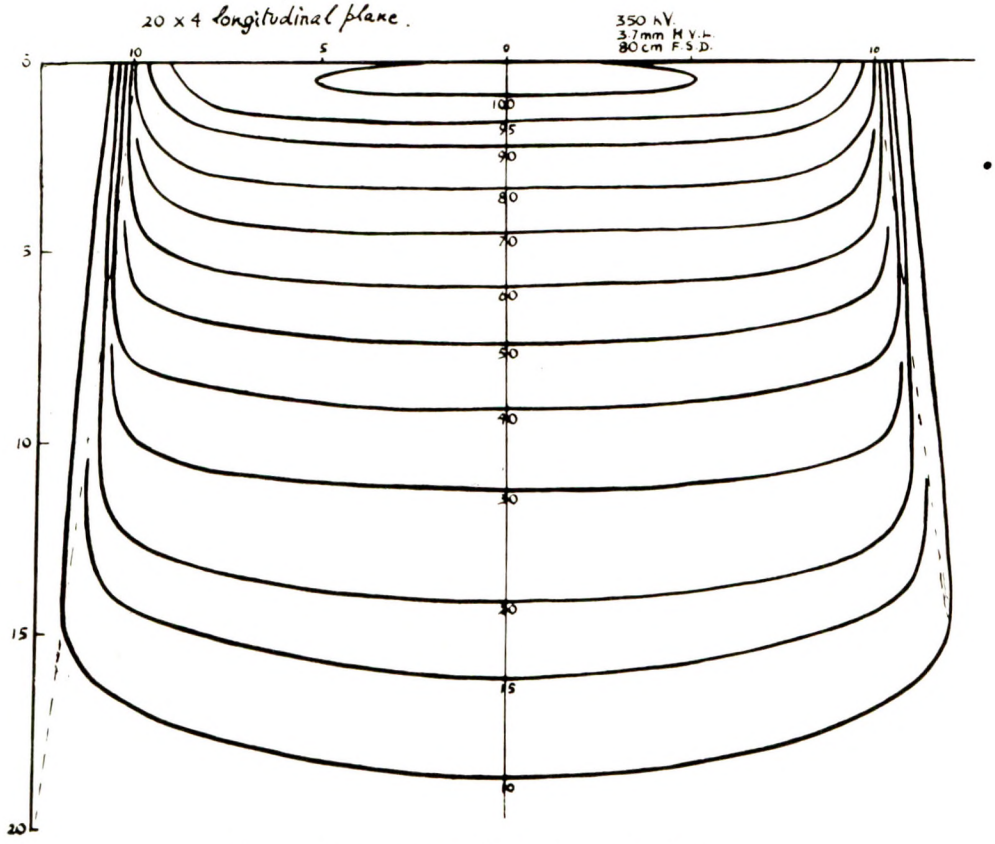


FIG. 17. Dose contours for the longitudinal plane.

Turning now to the isodose diagram for the longitudinal plane (Fig. 17) it will be noted that (1) there is a very small change in depth dose from the central axis to a distance of 8 or more centimeters at average depths; (2) there is a very rapid fall-off in dosage rate outside the geometrical edge of the field. To this and to the necessary widening of the field with depth is due the remarkable appearance of the dose distribu-

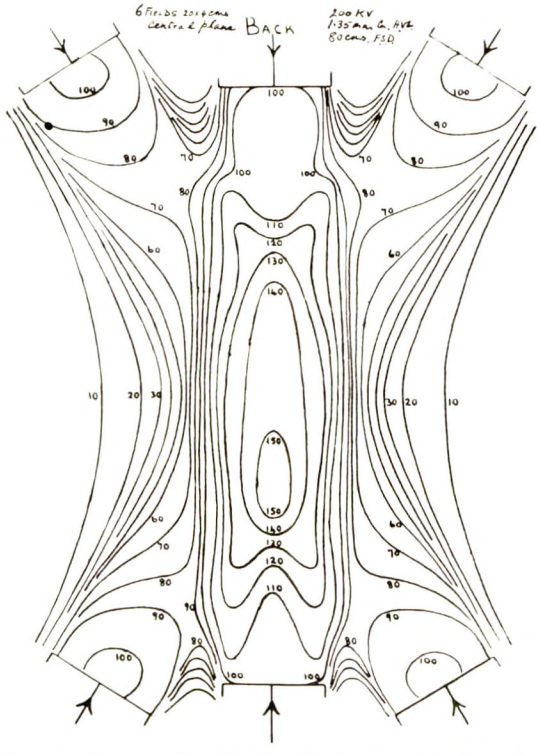


FIG. 18. Dosage distribution in the central plane for six fields each 20×4 cm. in size. 80 cm. focus-skin distance, 200 kv., 1.35 mm. Cu half-value layer (compare with Fig. 2, central plane).

tions in planes at 11 and 12 cm. from the center. Here while the surface dose is negligible, the dose at the center of the diagram is relatively large (Fig. 2, planes 11 and 12 cm. down from center).

Methods of Demonstrating Isodose Surfaces. It is of interest to be able to demonstrate the volume which would receive some definite dose during an average treatment. The model shown in Figure 3 was constructed to show the shape of the 140 per cent isodose surface and the position of the

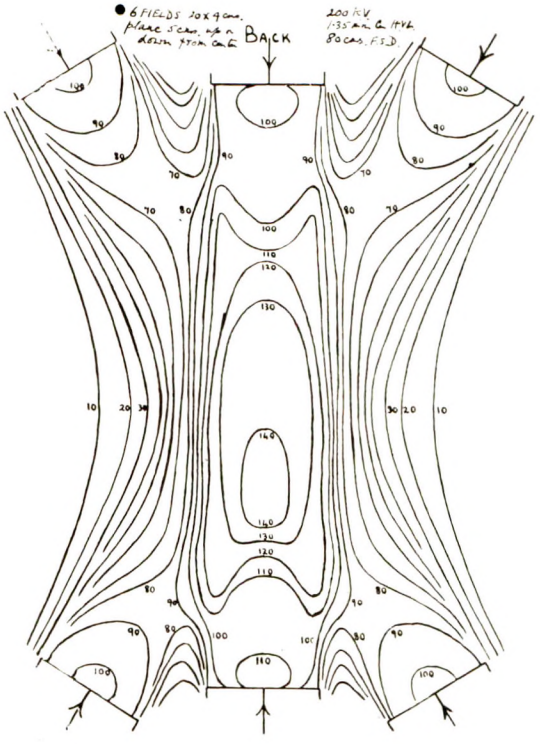


FIG. 19. Distribution in planes 5 cm. above or below that shown in Figure 18. (compare with similar planes, Fig. 2).

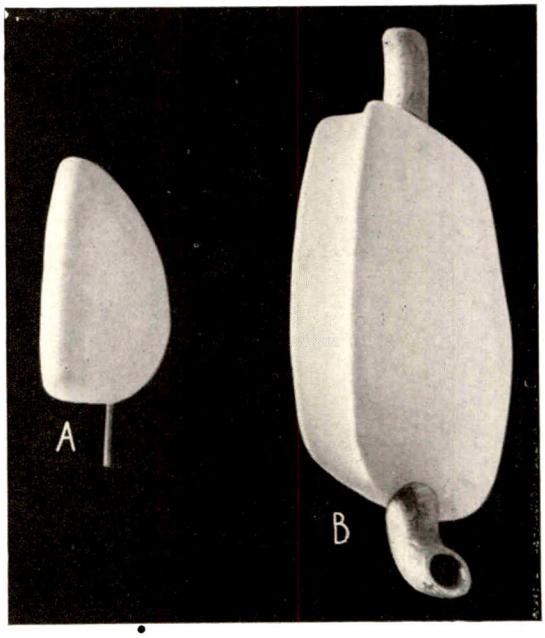


FIG. 20. 140 per cent isodose surfaces *A*, for 200 kv., 1.35 mm. Cu half-value layer, 80 cm. focus-skin distance; *B*, for 400 kv., 3.7 mm. half-value layer, 80 cm. focus-skin distance.

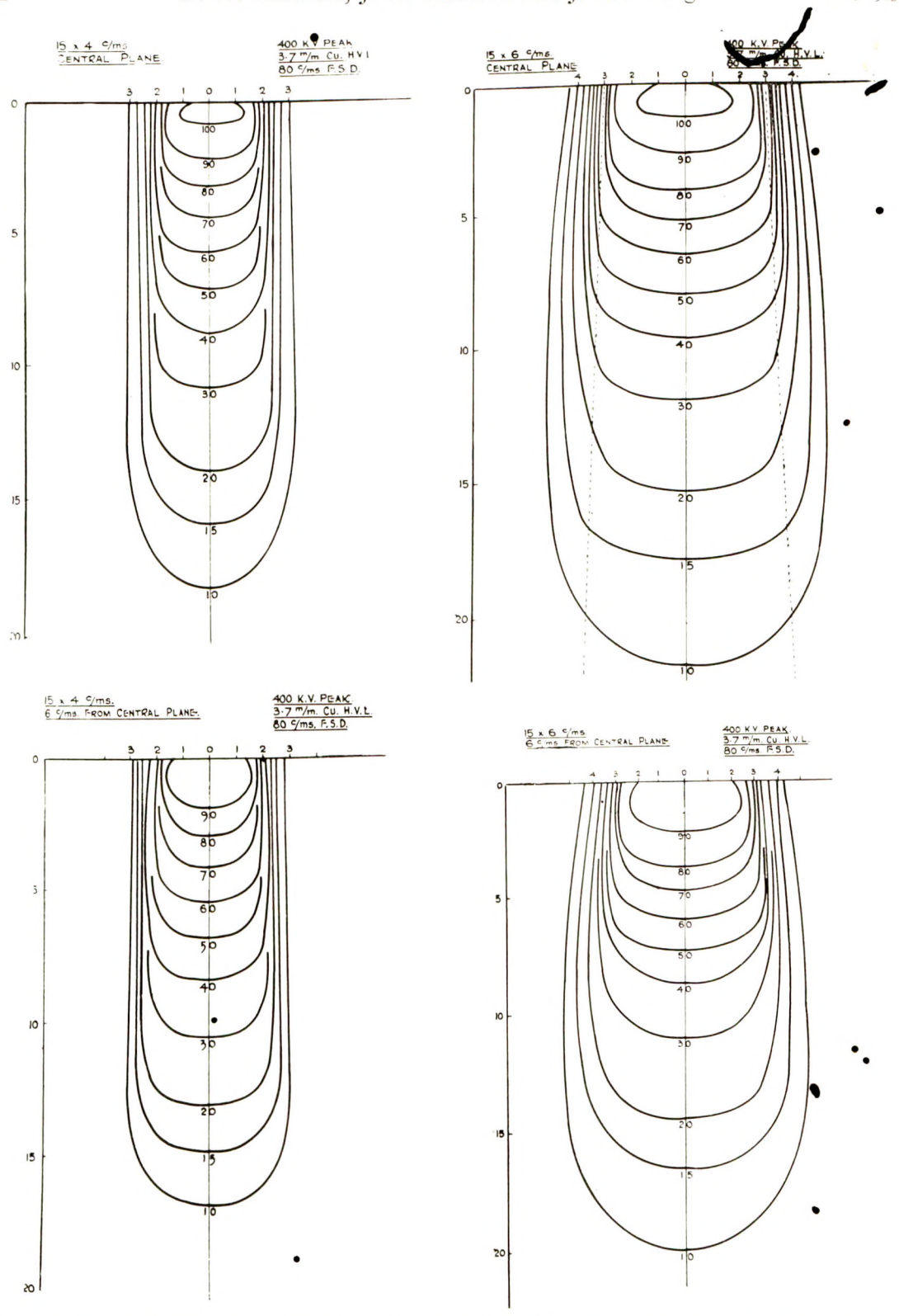


FIG. 21. Dose contours used in determining the tumor dose for each patient as described in Part I.

latter with relation to the outline of the body. The surface was made by fixing cardboard contours of the correct shape at the appropriate distances by separating them with wooden blocks and filling in the volume with plaster of paris.

As it may be desired to obtain dosage distributions in techniques where the strip fields are not applied with their longer dimensions mutually parallel, and where therefore the summation technique described is not applicable, it is useful to be able to use these dose contour diagrams on the dose finder described by Mayneord.[22] This may be done by mounting the diagrams, drawn on a transparent material such as glass or "Perspex," in a metal framework in the correct relative positions. This framework can be supported at the correct angle and position and doses read off with the dose finder. Interpolation will be assisted by making it possible to slide the contour diagrams together at intermediate positions.

As it may be of interest to consider the dosage distributions for a similar technique using radiation excited at 200 kv. having a half-value layer of 1.35 mm. Cu, dosage distributions have been worked out for the horizontal plane through the center of the fields and for a plane 5 cm. from this and parallel to it. These are shown in Figures 18 and 19. As before, a model has been made of the volume enclosed by the 140 per cent dose contour surface. It will be noticed that the surface obtained at 200 kv. is both shorter and narrower than for the more penetrating radiation (Fig. 20) and that the points of maximum dose tend to lie towards the front of the esophagus.

Distributions have also been worked out for a modified technique using four fields of 15×4 cm. and two of 15×6 cm. in rather different positions from those used with the 20×4 cm. fields (Fig. 6). The single-field distributions from which the complete diagrams were obtained are shown in the planes of chief importance in Figure 21.

Conclusion. The measurements made by Quimby, Copeland and Woods[26] in the chest of a cadaver indicate that even for penetrating radiation excited at 700 kv. depth doses are considerably higher than in water. This they ascribe to the air contained in the lungs. While it is realized that the application of physical measurements of dosage made in a homogeneous medium to the complex structure of the human body may be subject to some degree of uncertainty, it is considered likely that the results of Quimby, Copeland and Woods are not applicable to the present case in which narrow fields are arranged so as to avoid to a large extent irradiation of the lung spaces.

Acknowledgment: From the text it will be clear that the treatment of carcinoma of the esophagus by the method described demands the cooperation of the surgeon, pathologist, radiotherapist, physicist and nursing staff. We are greatly indebted to the whole staff of the Royal Cancer Hospital for their assistance. We are especially indebted to Professor W. V. Mayneord, the director of the Physics Department, for his help and advice, and to Dr. J. A. C. Fleming who kindly permitted us to see an, as yet, unpublished paper of his on carcinoma of the esophagus and to quote from it.

REFERENCES

1. Abel, A. L. Treatment of cancer of the esophagus. *Brit. J. Surg.*, 1926, *14*, 131–159.
2. Adams, W. E., and Phemister, D. B. Carcinoma of the lower thoracic esophagus. *J. Thoracic Surg.*, 1938, *7*, 621–632.
3. Baum, S. M. Esophageal-gastric carcinoma successfully treated by protracted fractional x-ray. *Radiology*, 1936, *27*, 58–62.
4. Bendick, A. J. Early esophageal carcinoma. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 603–604.
5. Broders, A. C., and Vinson, P. P. Degree of malignancy of carcinoma of esophagus. *Ann. Otolaryng.*, 1928, *8*, 79–80.
6. Buchbinder, W. C. Carcinoma of esophagus with especial reference to site. *Am. J. M. Sc.*, 1925, *170*, 496–499.
7. Carrié, C. Zur Therapie der Röntgenstrahlenleukopenie. *Strahlentherapie*, 1938, *63*, 183–187.
8. Clarkson, J. R., and Mayneord, W. V. "Quality" of high-voltage radiations; "quality" within scattering medium. *Brit. J. Radiol.*, 1939, *12*, 168–180.
9. Clayton, E. S. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1928, *46*, 52–62.
10. Fleming, J. A. C. To be published.
11. Guisez, J. Quelques remarques sur le cancer de l'oesophage. *Presse méd.*, 1937, *45*, 1135–1137.

12. HELSLEY, G. F. Metastazing tendency of esophagus carcinoma. *Ann. Surg.*, 1923, *77*, 272.
13. HILTON, E. L. G. Carcinoma of the esophagus. *Brit. M. J.*, 1937, *1*, 1281.
14. HONEYBURNE, J., LAMERTON, L. F., SMITHERS, D. W., and MAYNEORD, W. F. Symposium on 3-dimensional radiation distributions. *Brit. J. Radiol.*, 1939, *12*, 269–302.
15. IMLER, A. E., and WAMMOCK, H. *Vitamin* B_1 in irradiation sickness. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 243–248.
16. LEVITT, W. M. Treatment of carcinoma of esophagus by new method of deep x-ray therapy. *St. Barth. Hosp. Rep.*, 1935, *68*, 107–120.
17. LEVITT, W. M. Faculty of Radiologists: Radiotherapy Section discussion, January 20, 1940.
18. MCGIBBON, J. E. G. Clinical manifestations of spread of carcinoma of oesophagus observed during life. *Brit. J. Surg.*, 1936, *24*, 86–104.
19. MALCOLMSON, G. H., and MALCOLMSON, P. H. Cancer of oesophagus. *Canad. Med. Ass. J.*, 1937, *36*, 405–406.
20. MARTIN, H. E. Device for measuring diameters and the contours of cross-sections of the head and neck. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *25*, 536–537.
21. MAYNEORD, W. V. Optical device for accurate alignment of x-ray beam. *Brit. J. Radiol.*, 1939, *12*, 257–258.
22. MAYNEORD, W. V. Dose contour projector and application to 3-dimensional radiation distributions. *Brit. J. Radiol.*, 1939, *12*, 262–268.
23. MAYNEORD, W. V. Energy absorption. *Brit. J. Radiol.*, 1940, *13*, 235–247.
24. MERRITT, E. A. Radiation therapy of inoperable intra-abdominal malignancy. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 324–331.
25. NIELSEN, J. Klinische Versuche zur Strahlenbehandlung des Speiseröhrenkrebses. *Acta radiol.*, 1940, *21*, 352–367.
26. QUIMBY, E. H., COPELAND, M. M., and WOODS, R. C. Distribution of roentgen rays within the human body. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 534–551.
27. REGELSBERGER, H. Zur Behandlung des inoperablen Magenkarzinoms. *Strahlentherapie*, 1938, *61*, 201–232.
28. ROBERTS, F. Malignant disease of oesophagus. *Brit. J. Radiol.*, 1936, *9*, 732–742.
29. SOUTTAR, H. S. Treatment of carcinoma of the oesophagus. *Brit. J. Surg.*, 1926, *14*, 131–159.
30. STEVENSON, R. S. Early post-cricoid carcinoma. *Proc. Roy. Soc. Med.*, 1938, *31*, 661.
31. TOREK, F. First successful case of resection of thoracic portion of esophagus for carcinoma. *Surg., Gynec. & Obst.*, 1913, *16*, 614.
32. TOREK, F. Carcinoma of thoracic portion of esophagus. *Arch. Surg.*, 1925, *10*, 353–360.
33. WATSON, W. L. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1933, *56*, 884–897.
34. ZUPPINGER, A. Die Behandlung der Ösophaguskarzinome. *Ergebn. d. med. Strahlenforsch.*, 1936, *7*, 389–456.

VOL. 49, NO. 5

ROENTGEN THERAPY OF "VIRUS" PNEUMONIA

By ALBERT OPPENHEIMER, M.D.
Department of Roentgenology, Laconia Hospital
LACONIA, NEW HAMPSHIRE

THE atypical pneumonia which has come to be designated as virus pneumonia[2] seems to be refractory to medical treatment. According to inquiries made at numerous institutions, roentgen therapy has not been used so far in the treatment of this disease. Hence the results of roentgen irradiation in a fairly large group of cases should be recorded.

As during previous epidemics of influenzal pneumonia—to which virus pneumonia is at least very closely related—the disease varies somewhat with the locality and with its own epidemic course. For instance, at a time when numerous cases with massive consolidations were observed in the Boston district, only small peribronchial foci were found in the patients examined some seventy miles to the north, in New Hampshire. Pleurisy, which has been a fairly common complication in other parts of the country, has not yet been noted in the cases in northern New England. The severity and duration of the clinical manifestations seem to increase as the present epidemic extends. Moreover, at a given time, the symptoms differ from case to case and are sometimes stormy, sometimes rather slight. Apart from these variations, physicians are generally agreed on the distinctive features of virus pneumonia: fever and infiltration of the lungs lasting several weeks; persistent cough; no response to the sulfonamide drugs; and slow convalescence.

Two main types have been observed in New Hampshire: (1) a massive consolidation usually not confined to one lobe, but involving adjacent parts of contiguous lobes, mainly in the perihilar areas, casting ill-defined globular shadows; this is often bilateral, with one side much more extensively affected than the other; (2) a more diffuse patchy infiltration of both lungs along the bronchi, with definite enlargement of the hila, sometimes with small foci resembling miliary tuberculosis; this corresponds to the peribronchitis and pneumonitis of previous epidemics. A more detailed analysis of the roentgen findings has been published very recently.[6] The roentgenologic differences, however, are not associated with clear-cut clinical differences. The course, duration, and severity of the illness are not characteristic of the one or the other type in the instances observed in this district. During November and December, 1942, the leukocyte counts were low in the pneumonitis group (3,000 to 5,000), and high in the presence of massive infiltration (over 12,000); but this difference has not been noted in recent months. Since most of the patients had received sulfonamides before admission, these counts are not very significant.

After the febrile stage, which lasted anywhere between five days and six weeks, most of the patients continued coughing, chiefly at night. The cough did not respond to drugs, inhalation, steaming, and the like, and kept the patients awake for hours at a time. The impression was given that the resulting lack of sleep was one of the factors which delayed recovery. The cough could be controlled by roentgen therapy. This encouraged us to use roentgen therapy during the acute stages as well.

Although the results of roentgen therapy of lobar pneumonia are well known,[5] there is little information available on roentgen treatment of atypical pneumonias.[4,5] During the past ten years, I have treated nonneoplastic lesions, including bronchopneumonia, with roentgen doses corresponding to about one-third to one-fifth of those commonly advocated in the treatment of inflammations.[5] These small doses approximate closely the doses recommended by Chamberlain[1] in a paper which does not seem to be sufficiently known. For the treatment of virus pneumonia, the follow-

ing factors were used in this series: 130 to 150 kv., according to the size of the chest and the thickness of skin and muscles; 30 ma.; 0.5 mm. Cu plus 1 mm. Al filtration; 50 cm. anode-skin distance; an average dose of 50 r (measured in air) through portals covering the involved parts of the lungs usually 20 by 20 cm. This technique was adopted after treatment with 100 r or more at early stages had induced severe systemic reactions with chills, convulsions, and cold sweats in 3 instances. These reactions are known to occur after roentgen therapy of other infections,[5] but do not seem to be necessary for achieving the desired therapeutic result in our experience.

According to the observations of Fried and Heidenhain,[3] the amount of radiation applied should increase with the duration of the inflammation: the more recent the lesion, the smaller should be the dose administered. Accordingly, about 35 to 45 r was given to children, and 50 to 60 r to adults, during the first two or three days after the onset of symptoms; but 50 to 70 r and 70 to 90 r respectively when the symptoms had persisted for about one week previous to treatment. No untoward reactions of any kind were observed with this treatment. In the presence of leukopenia, roentgen therapy did not induce a further drop in the leukocyte counts.

The results obtained in 56 cases of virus pneumonia and pneumonitis are given in Table 1. None of the cases had previously responded to medical treatment; and the failure to respond to sulfonamide therapy was considered a diagnostic sign.

TABLE I

SYNOPSIS OF CASES

Number of Cases	Duration of Illness before Roentgen Therapy	Duration of Symptoms after Roentgen Therapy	Cured*	Not Cured†
18	2–5 days	1–2 days	14	
		3–5 days	4	
22	6–14 days	1–2 days	4	
		3–5 days	15	3
16	Over 14 days	1–3 days	2	
		4–7 days	6	8
Total: 56			45	11

* "Cured" means disappearance of fever and symptoms, but not necessarily of the pulmonary infiltrations, within the period of days mentioned (see the text).

† "Not cured" means that the symptoms did not completely subside within the period of days mentioned, although subjective improvement was sometimes noted.

The therapeutic effect of roentgen treatment varied to some extent with the duration of the disease prior to irradiation. As a general rule, a single treatment was sufficient to bring about a return of temperature to normal within sixteen hours, as well as a considerable diminution of the cough and distress, in patients treated within a few days after the onset of symptoms. About twenty-four hours after the treatment, expectoration usually increased moderately in these cases, and most of them were discharged from the hospital after another day or two. The annoying cough which troubles the convalescence of untreated patients did not occur at all in the cases treated early. When, previous to irradiation, the disease had lasted for over a

week, one treatment usually resulted in a drop of temperature to slightly above normal, but the coughing spells tended to persist, and the temperature often rose again after an interval of three or four days. In the cases of this group, a second treatment, sometimes followed by a third one after forty-eight hours, was necessary to obtain relief and drop of the temperature to normal. In 2 patients treated sixteen and twenty-three days after the onset of symptoms, several irradiations with increasing doses (up to 300 r) failed to effect any therapeutic results. These observations suggest that roentgen therapy of virus pneumonia is useful mainly during the early stages of the disease.

The clinical improvement did not coincide with a regression of the pulmonary infiltrations. The course of the resolution was checked on roentgenograms in all the patients. In general, clinical improvement or cure preceded the disappearance of the infiltrations by about four days, but a decrease in density and size of the corresponding shadows was often noticeable as early as thirty-six hours after the treatment. Residual infiltrations were not observed to persist in the patients treated.

Five patients were referred for roentgen therapy several weeks after termination of the febrile stage because of persistent cough at night, associated with fatigue and inability to resume normal occupation. These patients were treated with doses of 90 r three to four times in the course of about two weeks. They were free of symptoms after this time and regained normal health rapidly.

In the patients treated during the febrile stages, the disappearance of fever and distress was entirely undramatic. There was no evidence of a crisis. With surprising uniformity fever and symptoms subsided gradually in the course of about sixteen hours, during which period most of the patients spent their first comfortable night after days of discomfort and dyspnea. The rate of pulse and respiration returned to normal gradually at the same time. In view of the severe reactions observed after treatment with larger doses, as above mentioned, one may perhaps attribute this uneventful and gradual recovery to the small r doses administered in this series.

Clearly the results of any mode of treatment are very difficult to ascertain accurately and impartially, especially as regards acute infections. It certainly cannot be proved that the 56 patients of this series would not have recovered as rapidly without roentgen therapy. Control series are not easy to evaluate since, in clinical medicine, no two cases are exactly alike. In two pairs of treated and untreated patients the findings were similar enough to be comparable. Two males of about the same general build, aged fifty-six and sixty-three, showed an infiltration 11 cm. in diameter in the central part of the left lung, and a smaller one, about 4 cm. in diameter, in the right base. Both were severely ill, with rapid pulse and respiration, temperatures about 103° F., and moderate cyanosis. One of them was treated on the third day of his illness with 50 r; sixteen hours later the temperature had dropped from 103 to 98.3° F., pulse from 160 to 84, and respiration from 60 to 24. The infiltration was found definitely diminished forty-eight hours after the treatment, and the lung fields were found free of abnormal shadows five days after the treatment. There was a slight recurrence of the cough on the fourth day, but the patient remained free of symptoms from the fifth day on. The other patient was not treated during the first sixteen days of his illness, and the infiltration was found to have increased during this time.

The second pair consisted of two girls aged six, with bilateral diffuse pneumonitis. In the treated child, symptoms and lesions disappeared seventy-two hours after irradiation; in the untreated, they persisted for twenty-five days.

These two pairs of cases seem to bear out the experience of many physicians in various parts of the country in regard to the course of virus pneumonia in patients not submitted to roentgen therapy. If we may

use these many hundreds of untreated cases in lieu of a control series, it would seem to be evident that roentgen therapy helps to shorten the duration of the disease materially.*

SUMMARY

1. Roentgen therapy with small doses of between 35 and 90 r resulted in clinical cure within a few days in 45 out of 56 cases of virus pneumonia.

2. The pulmonary consolidations disappeared within three to five days after roentgen treatment.

3. The results of roentgen therapy were best at early stages of virus pneumonia, but limited when irradiation was used later than two weeks after the onset of the disease.

4. Roentgen therapy was the most effective mode of treatment for the control of the persistent cough which delayed complete recovery during convalescence in patients who had not received irradiation during the febrile stage.

5. At early stages, the r doses applied should be small. Treatment with doses exceeding 100 r during the early stages resulted in alarming systemic reactions. No untoward reactions whatever were observed with the use of smaller doses.

* No distinction was made between "virus" pneumonia of adults and the so-called interstitial pneumonia (peribronchitis and peribronchiolitis) of childhood, since the two diseases are identical epidemiologically and virtually indistinguishable in their clinical course. Children seem to respond to roentgen therapy more uniformly and within shorter periods than adults.

REFERENCES

1. Chamberlain, W. E. Roentgen therapy with very small doses. *Acta radiol.*, 1926, *6*, 271–280.
2. Editorial. Virus (?) pneumonia. *J. Am. M. Ass.*, Jan. 16, 1943, *121*, 197.
3. Fried, C., and Heidenhain, L. Röntgenbestrahlung und Entzündung. *Arch. f. klin. Chir.*, 1924, *133*, 624–665.
4. McIntire, F. T., and Smith, J. H. X-ray therapy in the treatment of pneumonia. *Texas State J. Med.*, 1937, *33*, 422–440.
5. Pendergrass, E. P., and Hodes, P. J. Roentgen irradiation in the treatment of inflammations. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 74–106.
6. Seeds, A. E., and Mazer, M. L. Virus pneumonia; roentgenographic characterization of recent virus pneumonitis with bronchopneumonia. Am. J. Roentgenol. & Rad. Therapy, January, 1943, *49*, 30–38.

Vol. 49, No. 5

RADIATION HAZARDS DURING ROENTGENOSCOPY*

By THOMAS N. WHITE, Ph.D.,† DEAN B. COWIE, B.S.,‡ *and* ALFRED A. DE LORIMIER, M.D.§

INTRODUCTION

HAZARDS associated with roentgenoscopy have been emphasized repeatedly;[2,3,4,5,10,26,27,29,31] yet the history of roentgenology contains too many accounts of mal-effects and martyrdom due to careless practices or unsuspected injurious action of the roentgen rays.[8] The mistakes of yesteryears should serve to counteract mal effects today, and in the future. Unfortunately, though, the provision of adequate protection during roentgenoscopy is inherently difficult. It appears that unless there is accomplished some major increase in the sensitivity of fluoroscopic screens,[9] the roentgenoscopist must continue to risk exposures beyond the accepted "tolerance dose," or be restricted by somewhat unwieldy protective equipment.

From time to time, our radiological societies have initiated careful deliberations and recommendations as to tolerance limits of roentgen radiation.[1,7,20,34,35] Most of these estimates have been based upon "injuries to the superficial tissues; changes in the blood and derangements of the internal organs." More recently emphasis has been directed to susceptibility of the reproductive organs.[21,32] The "tolerance dose" so estimated is about two-tenths of a roentgen per day. Biological studies have indicated reason for concern as to mal-effects upon future generations—a genetic effect.[17,19,25,33] The accepted tolerance dose is, to the best of present knowledge, fairly conservative as far as the first group of injuries is concerned. On the other hand, laboratory experiments show no evidence of genetic recovery from injury by roentgen radiation. Therefore the "tolerance dose" may not be conservative with respect to the population as a whole. Since damage of this character would be irreparable, it appears wise to hold to the lowest practicable level the exposure of the genital organs of all who can have offspring.

Following the impetus given to roentgenology during the first World War, there were advocated in Europe many elaborate protective devices. Line drawings of a few of these are shown in Figure 1. It is probable that some of these units provide a degree of protection considerably greater than is demanded by our present standard of "tolerance dosage." In the United States, devices such as these have not found wide favor. Indeed, there has been a tendency to dispense with most protective aids (including gloves and apron) and to depend upon the shielding afforded by the lead glass of the fluoroscopic screen, the use of small roentgen beams, and upon speed and skill of examination.[23] It should be unnecessary to re-emphasize that the elimination of protective apparel leads to undesirable conditions where carelessness, ignorance or undue confidence in modern equipment exist.[15,22,28]

Various types of roentgenoscopic equipment are available in this country today. Though not comparable to the arrangements which have been recommended by some of the European roentgenologists, we have so-called "heavy duty" table units wherein the roentgen tube and shutter housing are completely enclosed by a table provided with metal side panels; we have so-called "light duty" table units wherein the roentgen tube and shutter housing are exposed, beneath or behind the table top, and now we also have to be concerned with the extensive use of bare essentials—

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.
† Associate Biophysicist, National Cancer Institute, Bethesda, Maryland.
‡ Research Fellow, National Cancer Institute, Bethesda, Maryland.
§ Colonel, Medical Corps; Commandant, Army School of Roentgenology, Memphis, Tennessee.

roentgen-ray equipment such as might be practical for use in the battle field.

There appears to be much reason for an evaluation of exposure intensities associated with these three general types of equipment. Extensive studies have been made of the intensity of roentgen radiation in the exit beam under fluoroscopic conditions.[11,12,13,14,24] It is probably safe to say that exposure between the patient and the greatest exposure is incurred thereby. The studies have included the consideration of primary roentgen radiation escaping from conventional "ray-proof" roentgen tubes and the various components of secondary radiation such as that emitted from fluoroscopic shutters, shutter housings, table tops, the patient (i.e. phantom) and fluoroscopic screen. We have not included the consideration of gross errors or structural

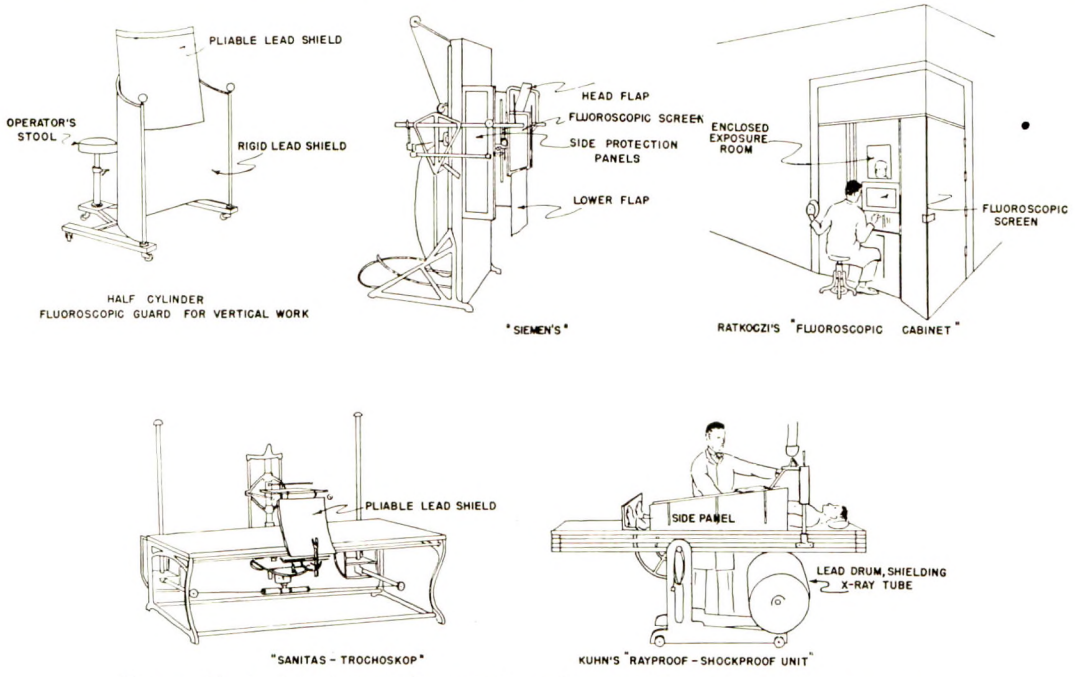


FIG. 1. Glocker's[18] choice of installations for protection during roentgenoscopy.

screen is practically independent of the type of table used. For this reason we have made few measurements at that location. On the other hand, few observers have given attention to exposure of the whole body of the roentgenoscopist, as affected by the general type of equipment. It is realized that the amount of radiation which a roentgenoscopist receives depends upon the physical protection provided by the equipment or shielding apparel, as well as upon the skill with which his work is performed. Just what are the dangerous conditions? What precautions should be observed?

The tests reported in this paper have been limited to conditions of horizontal roentgenoscopy, for it is believed that the flaws such as a misdirected primary beam or a "wide open" beam which might cover an area beyond the limits of the fluoroscopic screen.

OUTLINE OF EXPERIMENTAL PROCEDURE

Only the most essential experimental information is given in this section. Details which are not of general interest have been relegated to a technical appendix, to which the reader is referred by numbers prefixed by A.

The plan of this study was progressive. Starting with a "ray-proof" shock-proof roentgen tube, the leakage from which was first examined, there were added structural components typifying those of a horizontal fluoroscope: diaphragm (in place of shutters), filter, cone between tube housing and diaphragm, fluoroscop-

ic screen, two types of table top. After each addition the stray radiation was measured at suitable locations. From the changes in the amounts of stray radiation it was possible to assess the relative importance of the different structural components in adding to or reducing the stray radiation. There was then added a fiber board phantom (Technical Appendix A-1), roughly cubical in shape (about 20 cm. on edge); thereafter, an auxiliary shield between the diaphragm and the table top. These additions made possible a rough evaluation, at certain locations, of the secondary radiation from a patient, and the effect of the auxiliary shield upon the distribution of this radiation.

The side of the phantom on which these measurements were made was aligned roentgenoscopically with the border of the primary beam. Thus the full area of the beam was occupied by phantom material, while at the same time absorption of the secondary radiation emitted by the phantom was held to a minimum. Lateral additions of phantom material then permitted an evaluation, under well defined experimental conditions, of the extent to which body tissue *outside* the irradiated volume reduces the secondary radiation emitted *from* the irradiated volume.

The preceding tests were made with equipment possessing certain framework elements (not shown in the diagrams) which interfered to some extent with the free passage of secondary radiation from the phantom toward the lower levels. In order to overcome this difficulty and to provide a truer picture of the distribution of secondary radiation from a patient, both the apparatus and the phantom were reconstructed. The phantom was given an oval shape (Technical Appendix A-1) and distortion of the field of secondary radiation due to undesired structural elements was reduced to a minimum. Measurements were made at a sufficiently large number of locations to permit the construction of isodose (strictly speaking, isodose per unit time or iso-intensity) curves, showing graphically the distribution of the secondary radiation. There were determined the changes produced in this distribution due to a shift in the position of the phantom, and due to the addition of two common types of table.

Measurements of stray radiation were made with 0.25 r (full scale reading) condenser type Victoreen ionization chambers (Technical Appendix A-2). Actual exposure times ranged from one to six minutes. Since the total daily operating time of a roentgenoscopic roentgen tube is something like one hour (i.e., based on continuous operation), the intensities are presented in roentgens per hour, for easier comparison with the "tolerance dose" of 0.2 roentgen per day.

In some cases an indication of the penetrating power of the radiation was obtained by observing the reduction in chamber reading which was caused by wrapping the chamber with copper foil (Technical Appendix A-3). The results of these measurements are included mainly for possible future usefulness. So far as we know there is not at the present time sufficient information concerning the influence of quality of stray radiation on roentgen injury to warrant the drawing of any conclusions from these data.

Most of the measurements were made using 85 kv. (peak) and 5 ma., and with a shutter opening to give a field 20 by 20 cm. on the fluoroscopic screen, since it was considered that these conditions would give *more* rather than *less* than the average exposure. Occasional measurements, not recorded herein, showed that when the potential was reduced to 70 kv. (peak) and other conditions were kept constant, the secondary radiation intensity dropped by about 30 per cent. Enough measurements were made with a smaller field (10 by 10 cm. on the screen) to show the effect of field size.

OBSERVATIONS AND DISCUSSION

Due to the variety of factors involved in this experiment it has been thought best to discuss the observations as they are presented.

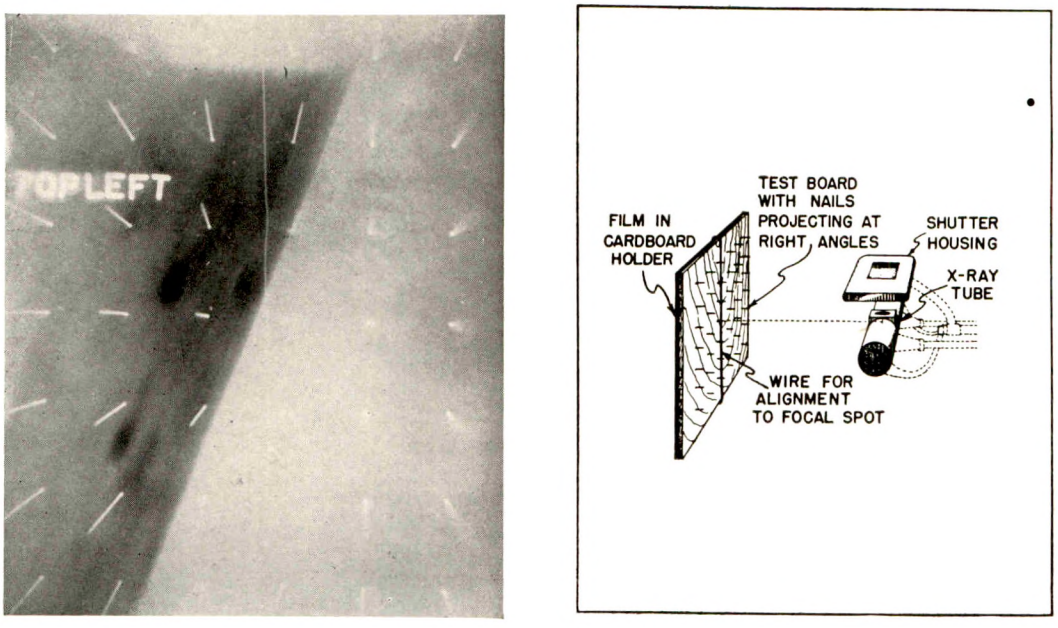
The Roentgen Tube. The shock-proof tube used for most of the tests had been purchased under specifications calling for "ray-proofing" to the extent of 1.5 mm. of lead, which is the amount of protection advocated by the National Bureau of Standards Handbook HB 20 for general purpose protection against 100 kv. radiation. Figure 2 shows roentgenographically the stray radiation obtained when the exit portal of the tube housing was blocked off with 3 mm. of lead, and the conditions under which the film was obtained. The escape of primary radiation is evidenced both by the sharp cut-off at the intersection of the plane of the target face with the film and by one set of sharp nail shadows, all pointing toward the projection of the focal spot thereon. The

more diffuse nail shadows must be attributed to secondary or to stem radiation (or both). The cut-off at the top of the film is attributable to the shutter housing shown in Figure 2*b*. The "nail-board" method appears to have certain possibilities which were not fully investigated in these tests.

Figure 3*a* shows the geometrical relations of film and roentgen tube more accurately, and also the positions at which ionization measurements were made before and after the addition of supplementary protection on the roentgen tube housing.

In horizontal roentgenoscopy it is quite possible for the operator's legs to be nearly as close to the roentgen tube as were the ionization chambers in this test. At this distance undesirably large readings were obtained before supplementary absorbing material was added to the tube housing. As would be expected, the leakage from the bare housing was very sensitive to the potential at which the tube was operating. A reduction to a potential of 70 kv. (peak) caused a decrease of more than 80 per cent in the reading at the x position. With a reasonable allowance for operating conditions and distance, these results agree with some of those obtained in Braestrup's thorough survey[6] of this subject.

Qualitative or quantitative testings were accomplished in no less than thirty-six different tubes or tube units. These represented constructions by six well recognized tube manufacturers and twelve established roentgen-ray equipment manufacturers. In every instance some escape of roentgen radiation was demonstrated—thus confirming the fact that the term "ray-proof" is in contradiction to the fundamental properties of roentgen rays. This term may be responsible for a false sense of security. Taylor's finding[30]—"It is thus seen that the internationally accepted protective lead thicknesses all apply, under average dosage rate conditions, to a point 150 cm. from the



a *b*

FIG. 2. Roentgenography of stray radiation from roentgen tube. *a*, film reproduction showing excess radiation (mostly primary) escaping from cathode sector ("top left"). Note the sharp demarcation of target face; also the multiplicity of the individual nail shadows—the more sharp and dense outlines being interpreted as being produced by primary radiation. *b*, showing the arrangement by which *a* was obtained.

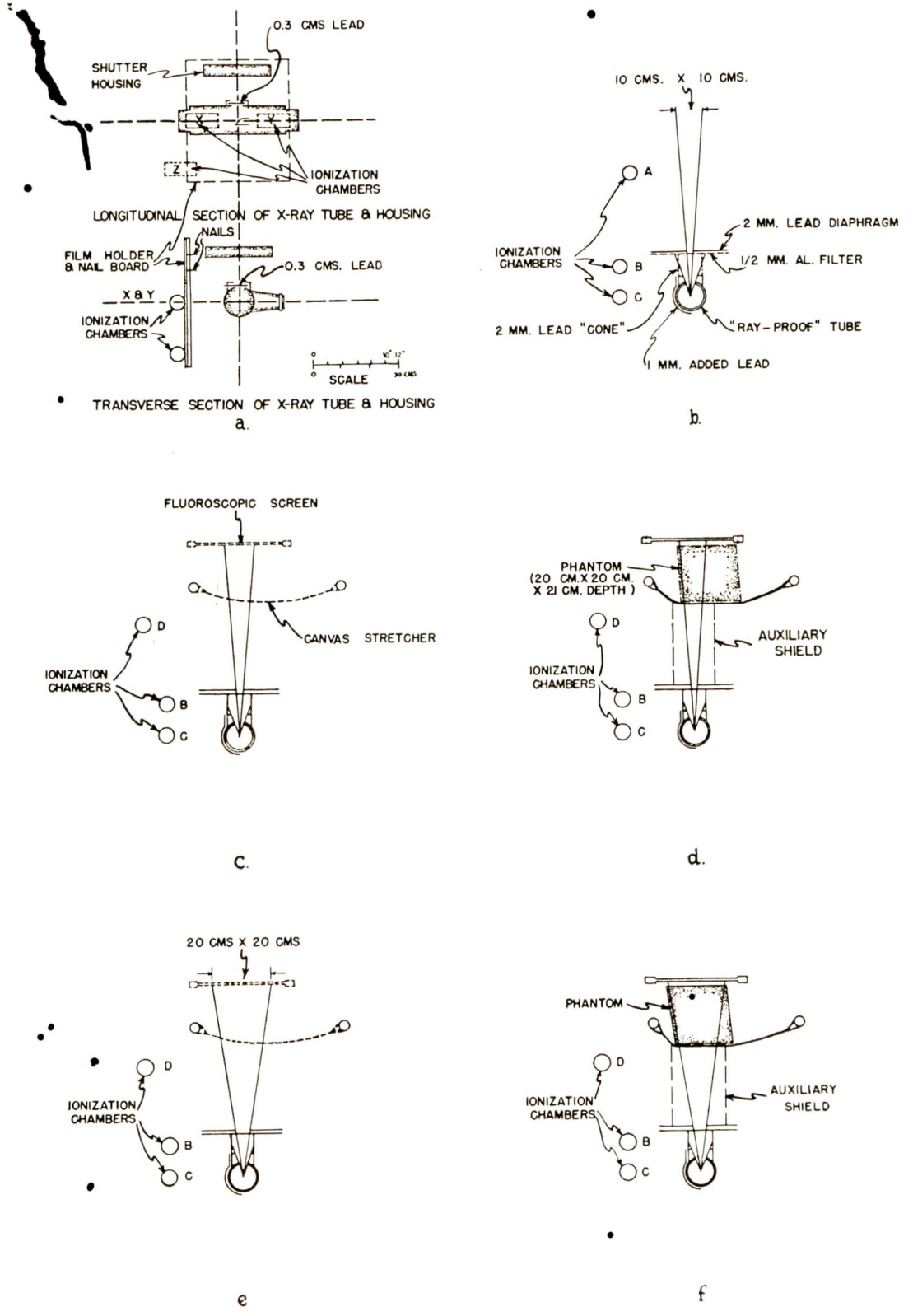


FIG. 3. Positioning of ionization chambers for progressive analysis of stray radiation emitted from the various components of a roentgenoscopic unit.

target"—deserves to be permanently recorded in the minds of all who must work close to operating roentgen tubes.

After adding an even more substantial absorber to the tube housing, the portal of the housing was opened, and the elements of a roentgenoscopic assembly were built up. The process is depicted in Figure 3, in which to avoid confusion, no more than two additions appear in any one diagram. Table 1 shows the effect of the additions with respect to intensities at the designated locations. Except as noted, the differences shown in the last column were obtained by subtracting the total roentgens per hour of one set-up from the total roentgens per hour of the next following set-up. It is recognized that in assigning significance to these differences, a certain degree of caution must be observed, since the effect of placing matter in a roentgen-ray field (either primary or secondary) is complex. Under the conditions of these tests certain increases or reductions in radiation can be assigned *mainly*, but not entirely, to certain causes, and the following discussion is subject to this qualification.

The Diaphragm (or Shutter) and Housing. In Figure 3*b* only a small fraction (about 19 per cent) of the primary beam passed through the opening in the diaphragm. The intensities observed at B and C differed little, therefore, from what would have been obtained had there been no opening in the sheet of lead. In view of the rather commonly held opinion that scattering from lead is less than scattering from matter of low atomic number, the effect of the addition of 0.5 mm. of aluminum is quite striking. Even with the filter present, the intensities below the level of the diaphragm are very large. It is clear that in special purpose equipment in which it is impractical to build the shutter housing onto the tube housing using absorbent material, some means must be found to cut off this radiation. The most desirable method must depend upon the type and use of the equipment, one example being given elsewhere.[16]

In conventional equipment, it is not practicable to bring a cone into contact with four shutter blades, and it is important therefore that the cone should extend into a protective structure which partially envelopes the shutters and associated operating mechanism. This is particularly important in the so-called "light duty" type of diagnostic table in which there is no metal side panel to absorb secondary radiation. The usefulness of substantial metal side panels in reducing secondary radiation from a patient is discussed later, but it should be mentioned here that we have found such panels to be very effective also in absorbing radiation from the tube side of shutter assemblies.

It will be noted that in this test the aluminum filter was placed in an unfavorable position with respect to the location designated as A in the diagram. Had the filter been placed at the exit portal of the tube housing, the final intensity at this position in Figure 3*b*, and the initial intensities at D in Figure 3*c* would undoubtedly have been even lower. The intensities obtained with nothing but air in the useful beam (the primary beam beyond the diaphragm) lead to an important conclusion: it is quite practicable to construct equipment such that there is practically no stray radiation other than that from solid matter in the useful beam. Obvious as this may seem, there is no difficulty in finding diagnostic units which do not meet any such basic requirement.

The Table Top and Screen. The radiation emitted from the table top and screen is ordinarily affected by the patient. However, it does occasionally happen that for one reason or another, the roentgen tube is energized with the shutters open and no patient on the table. The data indicate that under these conditions there is present an amount of stray radiation which is by no means negligible.

As would be anticipated, the secondary radiation from an ordinary table top ($\frac{3}{4}$ inch wood veneer with metal frame, borrowed from a conventional tilt table) is much greater than that from a canvas top (litter,

aligning the phantom as depicted in Figure 3. The addition of phantom material makes possible a determination of the protective effect of tissue outside the irradiated volume. Figure 4 shows the result so obtained with ionization chamber placed at the same level as the phantoms and at a distance of 21 cm. from the phantom. There was not much difference in absorption as dependent upon the potential at which the primary radiation was generated. The intensity of the secondary radiation was reduced to 50 per cent by traversal of about 3.5 cm. of phantom material. Since this thickness is considerably less than the amount of patient's tissue ordinarily expected to be present between the path of the primary beam and the roentgenoscopist, it is seen that the patient's body serves appreciably in reducing exposure. The protection so afforded is insufficient of itself, but it is well worth utilizing so far as clinical procedures permit.

TABLE I

Figure	Set-up	Position of Ionization Chambers	Total r per Hour	r per Hour Attributable to Added Component
3 *a*	(1) Exit portal of tube housing blocked with 3 mm. sheet lead	X	0.38	
		Y	0.20	
	(2) Tube housing enveloped by lead rubber—equivalent to 0.5 mm. lead	X	0.05	−0.33
		Y	0.02	−0.18
3 *b*	(3) Bare diaphragm (10 by 10 cm. portal at 66 cm. focal-screen level)	A	0.24	
		B	8.11	
		C	14.6	
	(4) Filter added (0.5 mm. aluminum)	A	0.30	+0.06
		B	2.5	−5.6
		C	3.1	−11.5
	(5) Cone added between tube housing and diaphragm (2 mm. sheet lead; diameter 9.5 cm.; length 8.5 cm.)	A	0.30	
		B	0.06	−2.44
		C	0.06	−3.04
3 *c*	(6) No change	D	0.06	
		B	0.06	
		C	0.06	
	(7) Fluoroscopic screen added (to level 66 cm. above focal spot)	D	0.30	+0.24
		B	0.12	+0.06
		C	0.12	+0.06
	(8) Canvas litter added as table top	D	0.30	very small
		B	0.12	very small
		C	0.12	very small
3 *d*	(9) Phantom added (21 cm. total thickness of fiber board—upon canvas litter as table top)	D	1.38	+1.32*
		B	.78	+0.72*
		C	.72	+0.66*
	(10) Auxiliary shield added between diaphragm and canvas litter table top	D	1.14	−0.24
		B	.06	−0.72
		C	.06	−0.66
3 *e*	(11) Diaphragm enlarged to produce 20 by 20 cm. portal at screen (compare 10 by 10 cm.)	D	0.18	
		B	0.12	
		C	0.06	
	(12) Canvas litter added as table top	D	0.36	+0.18
		B	0.24	+0.12
		C	0.18	+0.12
	(13) Conventional table top substituted for canvas litter	D	0.84	+0.48
		B	0.60	+0.36
		C	0.50	+0.32
	(14) Fluoroscopic screen added (canvas litter again in place)	D	1.14	+0.78†
		B	0.63	+0.39†
		C	0.48	+0.30†
3 *f*	(15) Phantom added	D	3.85	+3.67‡
		B	2.30	+2.18‡
		C	2.30	+2.24‡
	(16) Auxiliary shield added between diaphragm and canvas litter table top	D	2.76	−1.09
		B	0.12	−2.18
		C	0.12	−2.18

* Differences obtained by subtraction of total r/hr. of set-up (6).
† Differences obtained by subtraction of total r/hr. of set-up (12).
‡ Differences obtained by subtraction of total r/hr. of set-up (11).

Size of Portal. The data of Table 1 show that, as would be expected, the amount of secondary radiation from the phantom increases rapidly with the size of the beam. Measurements in connection with the oval phantom (see following) show the quantitative relationship more exactly.

Kilovoltage and Milliamperage Factors. The data of Figure 4 show that at equal currents the lateral component of secondary radiation from the phantom is greater at 85 kv. (peak) than at 70 kv. (peak) by from 55 to 85 per cent, depending upon the amount of intervening absorbing material. Other conditions being equal, the intensity of secondary radiation should be strictly proportional to the milliamperage. It follows that at 70 kv. (peak), 5 ma., and at 85 kv. (peak), 3 ma., the lateral scattering should be about the same, and in both cases about 40 per cent less than at 85 kv. (peak), 5 ma. It is of course understood that this percentage would not be expected to hold true for a comparison of 70 kv. (peak), 5 ma. on a chest with 85 kv. (peak), 3 ma. on an abdomen.

The Distribution of Secondary Radiation from Material in the Useful Beam. The following tests were performed to obtain a more detailed picture of the all-important secondary radiation from a patient, and to show the influence of certain important factors on this distribution. Figure 5 is self-explanatory, and little more need be said about procedure than that measurements were made at 6 inch horizontal and vertical intervals throughout the region where iso-

as used on United States Army Field Table).

The Phantom ("*Patient*"). With radiation of diagnostic quality very little of the primary beam is transmitted by a thick part of the body. Operating at 85 kv. (peak), primary transmission through the phantom of these tests was about 0.36 per cent. With a 20 by 20 cm. field on the screen the total radiation on the top side of the phantom was 0.11 r per minute in the absence of the screen. Of this amount about 16 per cent was primary radiation (Technical Appendix A-4). These observations are in substantial agreement with similar data obtained by Cilley, Kirklin and Leddy.[13]

From this it follows that in the presence of the phantom the screen could not have contributed appreciably to the radiation at the locations D, B, C. The effect of the phantom on the radiation from the table top is not easily ascertained. However, it has already appeared that little radiation is scattered from a canvas litter and the amount attributable to the phantom can therefore be estimated with sufficient accuracy by making subtractions in the way indicated by the asterisks in Table 1.

In agreement with previous investigators, it appears that the secondary radiation from the "patient" is of preponderant importance. Only in the case of the unprotected diaphragm was there found a greater amount of radiation from any other single component of the assembly. At the knee position of the operator, when large fields are used the radiation from the phantom is greater than that escaping from the bare tube housing (cf. position C and X). The ratio between these components depends of course upon the shutter opening. It appears that with a small portal (5 by 5 cm. on the screen), the radiation escaping from the tube housing might be the more important factor.

The Auxiliary Shield. The positions B, C, D were chosen at the outset to be sensitive to the effect of the final addition of the auxiliary shield. At position D the cylinder has a definite effect even though only a small fraction of the irradiated volume of the phantom is shaded from the "view" of the ionization chamber. With respect to lower levels, the shield is much more effective. The region throughout which any such shield affords protection will obviously increase with the area of the shield and its proximity to the patient. The present results may profitably be compared with those, presented later, which were obtained with a metal side panel on the table, since a "totally enclosed" table functions in certain respects like an auxiliary shield of maximum possible area.

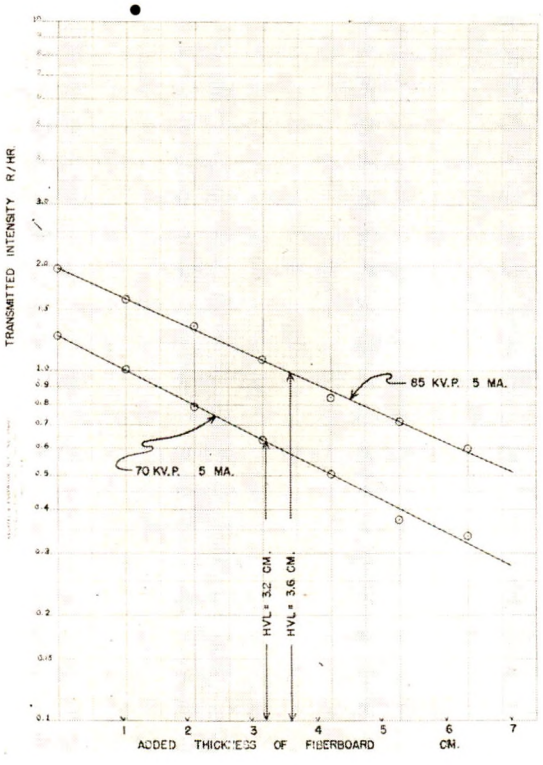


FIG. 4. Absorption of secondary radiation by phantom material (or patient's tissues).

Absorption of Secondary Radiation by the Phantom. Except for some of the secondary rays generated at the border of the primary beam, there must occur some absorption of secondary rays within the irradiated volume of the phantom. A direct investigation of this process is not readily accomplished. However, as previously mentioned, this factor can be reduced to a minimum by

dose curves are shown. Care was taken that there should be practically no stray radiation other than from material in the useful beam, and all auxiliary supporting structures were so disposed as not to distort the secondary radiation field under examination.

The conditions of roentgenoscopy are too complex to warrant any attempt at theoretical prediction of distribution of secondary radiation. There are, however, certain important factors, the magnitude of which can be estimated roughly, and an understanding of these factors is of aid in the mental integration of the experimental observations which follow. Confining attention to conditions similar to those with which we are here concerned, the most important considerations may be summarized as follows:

(1) Due to the strong and approximately exponential attenuation of the primary radiation, half the total scattering must occur in considerably less than half of the irradiated body volume. A reasonable estimate is that about half of the scattering occurs in the first 3 or 4 cm. of tissue traversed by the primary beam.

(2) Neglecting absorption of the scattered radiation, and taking the intensity of forward scattering as 100 per cent, the lateral and back scattering may be expected to be roughly 45 and 65 per cent respectively.

(3) Due to the situation set forth in (1) above, the radiation scattered in a forward direction must traverse, on the average, a much greater amount of tissue than that scattered in a backward direction. Due to absorption in tissue, the radiation which escapes in a forward direction must be weaker than that which escapes backward. An excess in the backward direction of 10-fold or more is to be expected.

While the backward versus forward aspect of the picture should be relatively insensitive to minor variations in size, shape or position of the body in the beam, this cannot be true of laterally escaping radiation. The amount of absorbing tissue traversed by laterally scattered radiation must depend rather critically upon these factors, and although even the roughest estimates are of little value, useful qualitative predictions can readily be made in the light of the considerations which have just been advanced.

Disregarding absorption, theory indicates that the radiation scattered in a backward direction should be somewhat less penetrating than that scattered in a forward direction. Differences in the amount of body filtration in these directions can only enhance this effect. It is therefore to be expected that appreciable differences will exist in the penetrating power of the rays escaping in different directions, those escaping in a general backward direction being definitely "softer" in character.

Discussing now the isodose curves* of Figure 5, we may return again briefly to the question of the influence of the size of portal. Under the conditions shown in Figure 5, A and B, the areas of the fields are 10 by 10 cm., 20 by 20 cm., respectively, and the ratio of the areas is therefore 1:4. In Figure 5A, the 0.60 r per hour isodose curve lies in the same position as the 2.4 r per hour curve in Figure 5B; the 0.30 r per hour curve in A has the same position as the 1.2 r per hour curve in B; etc. It is seen that the intensity of secondary radiation is nearly proportional to the area of the roentgen-ray beam on the fluorescent screen, other conditions being equal. The fact that this proportionality holds so accurately in this particular test is undoubtedly attributable to the symmetry of the conditions. Had the body been irregular in shape, or disposed asymmetrically in the beam, a change in the average absorbing path of secondary radiation would undoubtedly have led to some lack of proportionality.

It is to be noted that in Figure 5A the 0.15 r per hour curve occurs in such a position that the feet of the operator will not

* Appreciation is expressed for the care with which these many measurements were made by P. D. Kueck and Henry Meyer of the National Cancer Institute.

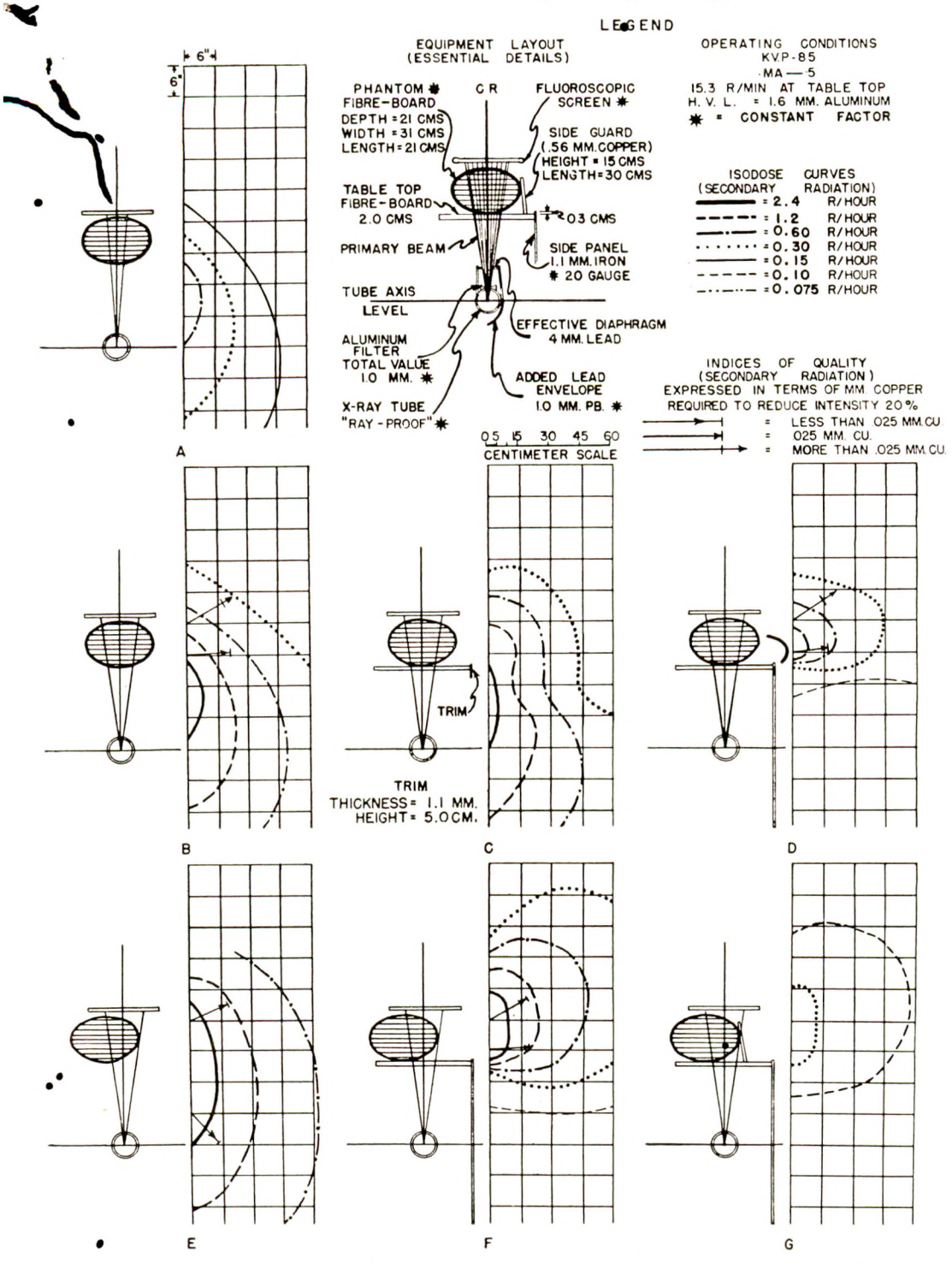


FIG. 5. Distribution of secondary radiation from phantom as affected by various roentgenoscopic conditions. A, primary field 10 by 10 cm.^{2} at level of fluoroscopic screen; phantom suspended immediately beneath screen—no table top. B, same as above except primary field was 20 by 20 cm. C, table top with iron trim added below phantom. D, iron side panel added; iron trim removed. E, same as in B but edge of beam grazing phantom. F, same as E with table top and side panel added—as in D. G, same as F with protective side guard.

receive an excessive dose even though these regions are unprotected. These observations support the emphasis placed by a number of investigators on the protective value of using the smallest practicable size of field.

Comparison of B and E (Fig. 5) shows the reduction in secondary intensity due to the presence of body tissue between the operator and the path of the primary beam in the patient's body. Alongside the phantom the intensity in Figure 5B is from one-half to one-fourth the intensity at corresponding points in Figure 5E.

A simple table top, such as is found in so-called "light duty" units, alters somewhat the distribution of secondary intensity. This alteration is of little practical significance. There is a slight increase in intensity at upper levels probably due to the fact that radiation from the table top can reach certain points without traversing as much of the phantom as required for the phantom radiation itself. At the level of the table top, and just below it, the table top provides some shielding due to the fact that many of the rays reaching this region have to traverse a long path through the material of the table.

At levels well below the bottom of the phantom, the relative distribution of secondary intensity is practically unaffected by any of the factors so far considered. With due allowance for the smaller beam energy of condition A (Fig. 5), the positions of corresponding isodose curves at the lower levels are practically the same in A, B, C and E. On the other hand, the intensity distribution of the more laterally emitted secondary radiation is quite sensitive to variation in conditions. These observations are in good agreement with the theoretical considerations which have been outlined.

The relatively strong field of secondary radiation below the level of the phantom can be practically eliminated by steel side panels of moderate thickness, such as may be found in many so-called "totally enclosed" roentgenoscopic tables. This is seen in D, F and G, Figure 5. It is to be noted, however, that the conditions of these tests differ in one respect from practical conditions in a table of this type, which ordinarily possesses a horizontal slot to permit loading of the cassette tunnel. Unless some accessory protective structure is present, a beam of secondary radiation can escape through this slot. A very satisfactory accessory would be a properly constructed auxiliary shield. As pointed out previously, the protective utility of this device depends upon its area, and proximity to the patient. It has been remarked by Braestrup[6] that on many tables there is considerable clearance between the "trochoscope cone" and the table, to avoid interference with the Potter-Bucky diaphragm. There have come to our attention only two tables in which construction was all that would be desired in this respect.

It is possible to obtain a many-fold reduction in secondary intensity at levels beside the phantom without completely walling off the area between the screen and the table top. Comparison of the results of test G with those of test F (Fig. 5) shows an 8-fold reduction produced by as little as 0.5 mm. copper extending over a little more than a half of this area. From time to time through many years, various investigators have advocated lead rubber curtains hanging from the sides of the screen, or similar devices. From the present results it can be seen that such devices have great protective effectiveness. Apparently practical problems of manipulating the patient have discouraged wider acceptance of them. It is our opinion that there is still the possibility of improvement in the compromise between requirements of protection and requirements of making an examination efficiently. However, even without any additional protective gadgets, minor modifications of procedures in the light of a clear mental picture of the secondary radiation field can go far in reducing exposure of the roentgenoscopist.

SUMMARY AND CONCLUSIONS

An evaluation of radiation intensities from various sources and for various strata,

applicable to the position of the roentgenoscopist during horizontal roentgenoscopy, has been accomplished by means of ionization measurements. These studies have indicated the following:

1. There is an escape of considerable roentgen radiation from conventional "rayproof" roentgen tubes. The term "rayproof" is misleading. Auxiliary protection such as a metal side panel or lead protective apron is often needed beyond the sphere of the roentgen tube housing. This supplementary protection is most needed when operating at relatively high potentials (e.g., above 80 kv., peak) and short distances (e.g., 12 inches from tube to legs of operator). It is especially important as far as the cathode end of the tube is concerned.

2. Large amounts of secondary radiation emanate from the irradiated side of lead shutters. Unless cut off by a cone extending from the tube housing to the shutters, or by some equivalent shield, this radiation is likely to overexpose the shins and feet of the roentgenoscopist.

3. With no patient present, the operator may still receive appreciable amounts of secondary radiation from the roentgenoscopic screen and from conventional table tops. The radiation from a very thin light table top, such as the United States Army litter, is very small.

4. The patient is usually responsible for by far the greatest amount of secondary radiation. The downward and outward components of this radiation are of the greatest intensity. In spite of their much greater distance from the patient, the unprotected legs of a roentgenoscopist could receive from this source exposures almost as great as would his unprotected hands if exposed to the exit beam between patient and the roentgenoscopic screen.

Metal side panels, such as are found on substantial totally enclosed tables of the "heavy duty" type, are very effective in cutting off this backscatter from the patient and table top. These panels are also of value as shields against the other sources of stray radiation mentioned in 1 and 2 above.

Tables which are not totally enclosed—"light duty" and field types—can provide nearly the same protection if equipped with a well designed auxiliary shield. The combination of such a shield on the table with a lead rubber apron on the roentgenoscopist is more protective than the "heavy duty" type of table alone.

5. The patient gives off secondary radiation in amount almost directly proportional to the dimensions (scope) of the primary beam. Thus, for example, with 20 by 20 cm. under examination on the screen the secondary intensity is at most points about four times as great as with only 10 by 10 cm. illuminated. This observation emphasizes again the importance of using the smallest field dimensions possible—a procedure beneficial in reducing the exposure of the patient as well as of the roentgenoscopist.

6. The amount of radiation scattered laterally by the patient is about the same at 85 kv. (peak), 3 ma. as at 70 kv. (peak), 5 ma. The difference in penetrating power of the radiations so scattered appears too small to be of practical significance. Thus, if equally good roentgenoscopic results are obtainable at 85 kv. (peak), 2 ma. as at 70 kv. (peak), 5 ma., the higher potential is preferable from the point of view of protection of the roentgenoscopist.

7. A considerable absorption of secondary radiation may occur in the tissues of the patient. When the primary beam is allowed to permeate those tissues nearest to the roentgenoscopist without there being any intervening portion between the limits of the beam and the lateral wall, the radiant intensity is about twice that which obtains when even so little as 3 cm. of tissue intervenes to filter the rays. This fact should serve as a warning against prolonged viewing of the lateralmost tissues of a patient, unless there is provided for the roentgenoscopist adequate protection (such as a lead rubber apron or a lead protective shield hanging from the screen).

8. The forward and lateral components of the secondary beam are of the more

penetrating quality of ray. Most commonly used types of equipment permit considerable exposure on the arms and shoulders of the roentgenoscopist from these rays. These facts prompt the recommendation that protective gloves of long dimensions be worn.

9. These studies have indicated that if the several sources of stray radiation are fully appreciated, satisfactory protection can be incorporated even into light and easily maneuverable equipment. If a lead protective apron and gloves are worn by the operator to supplement well designed built-in protection, he can realize security against roentgen radiation exposure, except for very limited portions of his body such as his arms and shoulders, perhaps. Except for these parts, the exposures can easily be kept well below conservative estimates of the tolerance dose; well below 0.04 r per hour, with the consideration of continuous roentgenoscopic activity or less than 0.1 r for a strenuous ten hour day of intermittent roentgenoscopy. It should be borne in mind and emphasized that with *any* of the present day equipment (well designed "heavy duty," "light duty" or Army field units), a considerable exposure is incurred by parts of the body such as the shoulders—a quantity of the order of ten times the accepted tolerance dose.*

We wish to express our appreciation to Sergeant H. B. Kline of the Army Medical School for the several drawings.

TECHNICAL APPENDIX

A-1. Phantom consisted of blocks of fiber board, commonly called "masonite," average thickness, 0.53 cm.; average density, 1.04 gm/cc.

The "oval" phantom was constructed by cutting fiber board sheets and stacking them together so that the contour approximated closely an ellipsoidal cylinder of major axis 31 cm., minor axis 21 cm., length 20 cm. The stack was bound together with twine.

A-2. There was some concern as to trust of conventional ionization chambers for these measurements because of the relatively long wave length characteristics of the beam and the thickness of the wall of the chambers. Therefore a test run was conducted using a chamber with a graphited paper wall. With it the readings were only 6 per cent greater when operating at 85 kv. (peak) or 7 per cent greater at 70 kv. (peak)—both as compared with tests with the conventional wall. A constant error of this magnitude was considered unimportant for these comparative studies and therefore the standard chamber was used throughout.

A-3. The quality of roentgen radiation is ordinarily determined using absorbers placed at some distance from the ionization chamber, in order to avoid the effects of secondary radiation from the absorber, which may be quite considerable. In cases such as this, where the source of measured radiation is extended over a considerable volume, and different intensities are being received from different directions, the technique chosen appeared to be preferable to the more conventional procedure. On account of the quality of the radiation, aluminum would have been preferable to copper, but none was available in suitable form at the time the measurements were made.

A-4. Discrimination between primary and secondary radiation was accomplished in the following way: It was assumed that above the phantom the radiation consisted of two components, a primary component varying inversely as the square of the distance from the focal spot, and a secondary component varying inversely as the square of the distance from some unknown point in the phantom. On this basis there was derived a simple formula containing three arbitrary parameters which could be adjusted to obtain reasonable agreement with a series of measurements at different distances above the phantom. The values of two of these parameters were then sufficient to determine the intensities of the primary and secondary components at the upper surface of the phantom.

REFERENCES

1. American Roentgen Ray Society, Proceedings of the Annual Meeting, 1920.
2. Barclay, A. E. Dangers of roentgenoscopy. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 699–700.
3. Barclay, A. E., and Cox. S. Radiation risks of the roentgenologist. Am. J. Roentgenol. & Rad. Therapy, 1928, *19*, 551–561.
4. Benner, S. Strahlungsmessungen an mit radiologischen Arbeiten beschäftigtem Personal. *Acta radiol.*, 1933, *14*, 623–629.
5. Bouchacourt, L. Sur la protection des radiologistes pendant les examens radioscopiques. *J. de radiol. et d'électrol.*, 1930, *14*, 489–494.
6. Braestrup, C. B. X-ray protection in diagnostic radiology. *Radiology*, 1942, *38*, 207–216.
7. British X-ray and Radium Protection Committee. X-ray and radium protection. *J. Roentg. Soc.*, 1921, *17*, 100–103.
8. Brown, Percy. American Martyrs to Science through the Roentgen Rays. Charles C Thomas, Springfield, Ill., 1936.

* For discussion see page 659.

9. CHAMBERLAIN, W. E. Fluoroscopes and fluoroscopy; Carman lecture. *Radiology*, 1942, *38*, 383–413.
10. CHANTRAINE, H., and PROFITLICH, P. Ueber den Schutz des Arztes und seiner Gehilfen vor den Röntgenstrahlen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 121–128.
11. CILLEY, E. I. L., LEDDY, E. T., and KIRKLIN, B. R. Dangers of roentgenoscopy and methods of protection against them. II. Some considerations of the size of the beam used in roentgenoscopic examination. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 805–807.
12. CILLEY, E. I. L., LEDDY, E. T., and KIRKLIN, B. R. Dangers of roentgenoscopy and methods of protection against them. III. The protective power of the barium-filled stomach. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 88–92.
13. CILLEY, E. I. L., KIRKLIN, B. R., and LEDDY, E. T. Dangers of roentgenoscopy and methods of protection against them. IV. A detailed consideration of the doses received by the fingers of the examiner. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 390–395.
14. CILLEY, E. I. L., LEDDY, E. T., and KIRKLIN, B. R. Dangers of roentgenoscopy and methods of protection against them. V. Some considerations of the "dose" received during examination of the colon. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 787–792.
15. COWIE, D. B., and SCHEELE, L. A. Survey of radiation protection in hospitals. *J. Nat. Cancer Inst.*, 1941, *1*, 767–787.
16. DE LORIMIER, A. A., COWIE, D. B., and WHITE, T. N. Protective features provided with the United States Army field roentgenoscopic equipment. AM. J. ROENTGENOL. & RAD. THERAPY, May, 1943, *49*, 653–661.
17. DEMEREC, M. Heredity and radiation. *Radiology*, 1936, *27*, 217–220.
18. GLOCKER, R. Prinzipien des Strahlungs- und Hochspannungsschutzes und ihre technische Durchführung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 241–253.
19. HENSHAW, P. S. Biologic significance of tolerance dose in x-ray and radium protection. *J. Nat. Cancer Inst.*, 1941, *1*, 789–805.
20. INTERNATIONAL X-RAY AND RADIUM PROTECTION COMMISSION. International Recommendations for x-ray and radium protection. *Radiology*, 1934, *23*, 682–685.
21. INTERNATIONAL X-RAY AND RADIUM PROTECTION COMMITTEE. International Recommendations for x-ray and radium protection. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *40*, 134–138.
22. LEDDY, E. T. Causes of roentgen-ray dermatitis among physicians. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 510–512.
23. LEDDY, E. T. Dangers of roentgenoscopy. (Editorial.) AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 924–927.
24. LEDDY, E. T., CILLEY, E. I. L., and KIRKLIN, B. R. Dangers of roentgenoscopy and methods of protection against them. I. General review of the problem. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 360–368.
25. MULLER, H. J. The effects of roentgen rays upon the hereditary material. Chap. XVII in: The Science of Radiology. Otto Glasser, Editor. Charles C Thomas, Springfield, Ill., 1933.
26. PETZOLDT, H. Ionometrische Messungen des Strahlenschutzes in medizinischen Röntgeninstituten. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1934, *49*, 406–415.
27. SCHLECHTER, E. Streustrahlenschutz in der Diagnostik. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, *34*, 946–950.
28. STEVENSON, C. A., and LEDDY, E. T. Dangers of reducing fractures under the roentgenoscope and methods of protection against them. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *37*, 70–82.
29. TAFT, R. B. Stray radiation under actual conditions. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *46*, 373–375.
30. TAYLOR, L. S. Economic features of x-ray protection. *Radiology*, 1940, *34*, 425–437.
31. TAYLOR, L. S. Roentgen-ray protection. Chap. XIX in: The Science of Radiology, Otto Glasser, Editor. Charles C Thomas, Springfield, Ill., 1933.
32. TAYLOR, L. S. X-ray protection. *J. Am. M. Ass.*, 1941, *116*, 136–140.
33. TIMOFÉEFF-RESSOVSKY, N. W. Experimentelle Mutationsforschung in der Vererbungslehre. Theodor Steinkopff, Dresden, 1937.
34. X-RAY PROTECTION. National Bureau of Standards Handbook No. 15, 1931.
35. X-RAY PROTECTION. National Bureau of Standards Handbook No. 20, 1936.

Vol. 49, No. 5

PROTECTIVE FEATURES PROVIDED WITH THE UNITED STATES ARMY FIELD ROENTGENOSCOPIC EQUIPMENT*

By ALFRED A. DE LORIMIER, M.D.,† DEAN B. COWIE, B.S.,‡
and THOMAS N. WHITE, PH.D.§

INTRODUCTION

PROTECTIVE features, concerned both with electrical and radiation hazards, are usually provided at the cost of increased bulk and weight. They might readily be overlooked where ease of manipulation and maneuverability are required Yet these features are of the greatest importance to such equipment, particularly when it is to be used under conditions of stress such as characterize activities in the Zone of Combat.

At first sight, our Army field roentgenoscopic equipment may present the appearance of shortcomings so far as protection from roentgen radiation is concerned. The provisions which have been incorporated into the design of our two types of table units may not be immediately evident. At least they have not been noted by a number who have spoken or written about this equipment.

For instance, one well qualified roentgenologist wrote as follows: "I understand that Dr. —— has just reported that a Field X-ray Unit scatters considerable radiation and the amount radiating to the head and neck is greater than the daily tolerance dose. Because of this I am extremely anxious to protect my men and myself from excessive exposure. I would rather have just one or two x-ray machines and be adequately protected than to have a display of eight or nine machines and have no protection."

The expression of another has been published as follows: "It looks to me to be the most flagrant violation of the rules of fluoroscopy that I have ever seen."

Such expressions appear to have become widely heard. They have reached the ears of roentgen-ray technicians. Frequently, we have received inquiries such as the following: "What are the needs for roentgenographic technicians in the Service? I understand that there is a considerable hazard associated with this work in the Army. A friend told me that one is likely to become sterile in the course of such an assignment; is this true?"

Our usual explanation has been that no hazard exists without carelessness in use of the equipment and that no harm is to be expected as a result of roentgenologic activities with the Army, for adequate protection has been provided.

It is doubtful if the usual brief and categorical assurances can dispel entirely the fears which have prompted these remarks and inquiries. Yet time has rarely been available to give more detailed and satisfying answers.

Actually, there has been considerable thought about this matter. The basic design provided many features of protection and the several manufacturers* have cooperated to the greatest extent. They have never hesitated to incorporate improvements beyond the requirements described in our specifications and they have initiated considerable investigation themselves.†

The fundamentals pertaining to the vari-

* Appreciation is expressed to the X-ray Division of the Westinghouse Electric and Manufacturing Company, who have been constructing the all-purpose table unit; to the Picker X-ray Corporation, who have developed the lighter weight essentially roentgenoscopic unit, and to the H. G. Fischer Company, who also are engaged in manufacturing the larger unit.

† Particular respect is paid to Mr. E. R. Goldfield of the Picker X-ray Corporation for the very detailed testings which have been performed under his supervision.

* Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.
† Colonel, Medical Corps; Commandant, Army School of Roentgenology, Memphis, Tennessee.
‡ Research Fellow, National Cancer Institute, Bethesda, Maryland.
§ Associate Biophysicist, National Cancer Institute, Bethesda, Maryland.

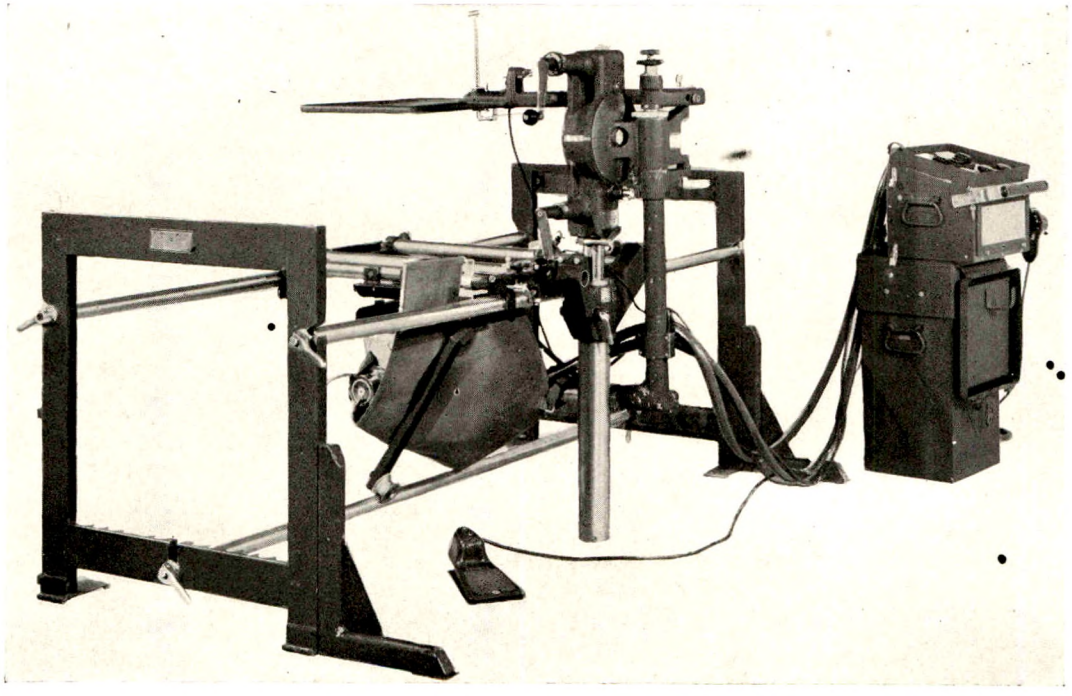
ous sources of radiation exposure have been described elsewhere.[3] Since the Army field equipment has been supplied in such great numbers and since it is being used by so many roentgenologists, it would seem appropriate to describe the protective features which have been provided.

PROTECTIVE FEATURES COMMON TO THE TWO ARMY ROENTGENOSCOPIC UNITS (FIG. 1)

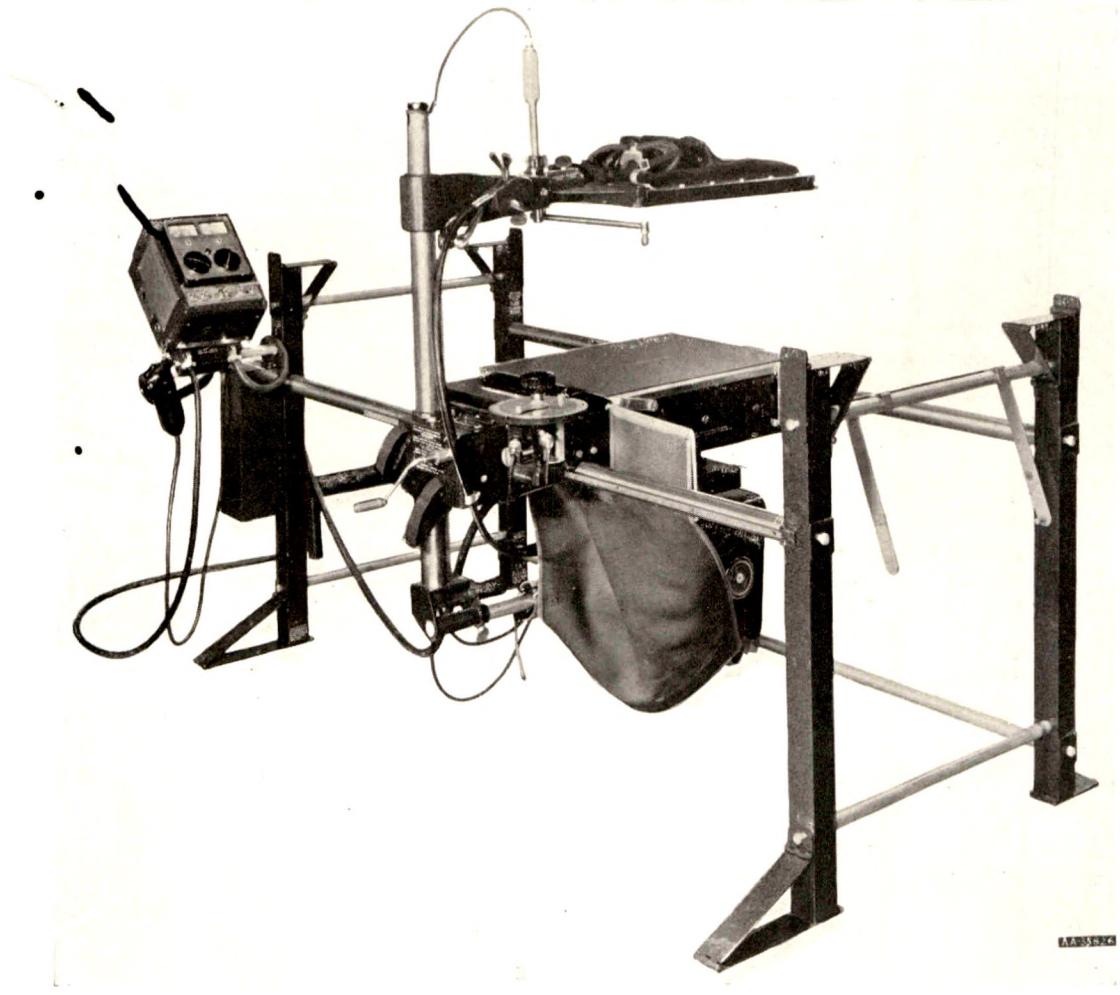
1. For roentgenoscopy, there is a fixed focal-roentgenoscopic screen alignment and distance (66 cm.). This feature serves to obviate mal-alignments of the primary beam or changes in the coverage of it by the roentgenoscopic screen as might apply in case the roentgenoscopic screen were allowed to move independently in relation to the roentgen tube. Many have advocated the use of a bonnet type of roentgenoscope which might be carried on the head of the operator to permit conducting these activities in a lighted room. This plan, and others similar to it, were rejected for the very reason that they would incur too great a hazard of roentgen-ray exposure.

2. The area of the roentgenoscopic screen is 12 by 16 inches, providing a large roentgenoscopic field and therewith a large area of protection against secondary radiation from the patient. Many have recommended that in order to reduce the weight to a minimum and to facilitate the exchange of patients, the dimensions of the roentgenoscopic screen should be 10 by 10 inches, as used in the first World War. These advantages were sacrificed in favor of protection.

3. During foreign body localization, the skin surface can be marked by a special device[2] which can be manipulated *beneath* the roentgenoscopic screen but without exposing the hands of the operator to the primary beam. This is made possible because, with the method of localization which is used, the distance between the roentgenoscopic image and the skin surface is subtracted in the final adjustment of the depth scale, and it is not necessary to position the roentgenoscopic screen directly upon the skin surface. If the latter design were used, a perforation for admitting a



A



B

FIG. 1. The two United States Army roentgenoscopic units. *A*, the heavier but more versatile unit,[1] designed for all types of hospital installations where transportation is not too great a problem. *B*, the lighter weight unit, designed for usage for Air Service and for locations not easily accessible by motor transportation.

skin marker would be required, with resultant escape of secondary radiation as well as some primary radiation and exposure of the face of the operator, as occurred with equipment used in the first World War.

4. Stops are provided to limit the opening of the roentgenoscopic shutter so that the border of the primary beam is restricted to at least 1 inch within the protective limits of the roentgenoscopic screen (cf. features 1 and 5). Thus, even with the most careless operation of the shutter controls, it is not possible for any part of a primary beam to escape beyond the limits of the protection provided by the roentgenoscopic screen and its lead protective glass (protection equivalent to no less than 1.5 mm. lead).

5. The roentgenoscopic screen and the roentgen tube are mounted on a C-shaped support which is adjustable in the vertical plane, thus permitting variation of the focal skin distance and utilization of the greatest focal skin distance possible during localizations—and the least part-screen dis-

tance. This feature serves to minimize roentgen radiation exposure of the patient and concurrently to reduce secondary radiation from the tissues. It is of advantage to utilize this provision for it also provides for the optimum of visualization by improving contrast and sharpening detail.

6. Except for the portal for exit of the primary beam, the roentgen tube housing is impregnated with material possessing a protective equivalence of no less than 1.5 mm. lead.

7. Through the portal intended for the primary beam, the combined inherent filtration is equivalent to 0.5 mm. aluminum. This filtration consists of the wall of the insert tube (1.0 mm. pyrex glass), a thin layer of oil (1.5 mm.), a transparent bakelite wall (1.5 mm.) plus an added fixed filter of 0.25 mm. aluminum. Thus unnecessary soft radiation has been eliminated while retaining intensity sufficient for roentgenography.

8. For roentgenoscopy, in addition to the filter just described, there is a second fixed filter of 0.5 mm. aluminum. This filter is fixed into the housing of the roentgenoscopy shutters. Thus, the total filtration during roentgenoscopy is consistent with the stipulation contained in paragraph 2.03 of Handbook HB-20 as compiled by the Advisory Committee on X-ray Protection and as published by the National Bureau of Standards.

9. The shutter controls are contained in the vertical portion of the C-shaped supporting member, referred to above, at a liberal distance from the primary beam and the sources of secondary radiation. This feature serves to minimize the exposure incurred by the examiner's forearm, and moreover it lessens the tendency for him to lean closely toward the side of the patient, whereby he would receive more extensive exposures.

10. The method of foreign body localization is such that only three short exposures for alignments are required. The localization procedure can easily be accomplished within thirty to forty-five seconds whereby even with the very shortest focal skin distance (10 inches—allowing for a very heavy patient, a very old litter) and using 85 kv. (peak) and 5 ma., the dose at the skin of the patient would be approximately 15 roentgens. The reading of the depth scale and the calibration scale can be made only while the roentgen-ray exposure is interrupted, this feature being in contrast to so many methods which provide for reading of measurements with the assistance of fluorescence from the roentgenoscopic screen

11. An adjustable limiting resistance is incorporated into the control so that when the thumbswitch or footswitch is used (either being required for roentgenoscopy) the maximum milliamperage load can be limited to 5 ma. or any lesser value.

12. The fastest type of roentgenoscopic screen is provided, minimizing exposure requirements to the utmost.

13. The table top is a standard United States Army litter. It is constructed of materials of low atomic number—canvas and aluminum. The secondary roentgen radiation emitted from a litter type of table top is considerably less than that emitted from conventional table tops and thus this source of secondary radiation is relatively reduced.

14. A lead impregnated apron and a pair of lead impregnated gloves are part of the contents in the field chest which accommodates the control unit of the roentgen-ray machine. Thus, it is certain that at least one lead apron and one pair of gloves will be taken to every installation where the roentgen-ray machine unit is to be operated. The United States Army does not suggest; it *enforces* the wearing of a lead apron and lead gloves while using field roentgen-ray equipment. Samples of these items are tested at the Army School of Roentgenology and unless their quality is up to standard, including the requirement that a single thickness of either shall provide protection equivalence of no less than 0.5 mm. lead, these items are rejected. The supporting straps of the aprons provide for suspension from one shoulder to the oppo-

site hip—rather than from the neck—thus giving the maximum of comfort in the wearing of these otherwise cumbersome garments. The standard gloves have a length of 37 cm., which is somewhat longer than gloves commonly used in many clinics.

15. An auxiliary lead impregnated shield is supplied as a separate item. It can be adapted to either end and to either side of either of the two official table units. Thus, this item has an eight-way adaptation. It is carried as a separate item, as are the apron and gloves, for all three can be expected to deteriorate. The auxiliary shield is designed to protect the legs of the operator below the bottom of the lead rubber apron. With it the operator and attendants or observers are protected throughout the arc of greatest intensities of scattered radiation—considering the lateral and downward trajectories with respect to the roentgen tube and screen.[3]

16. Several types of instruction manuals are provided. They have been issued by the several manufacturers as well as by the Army. In particular, technical manual TM 8-275 includes a chapter dealing with roentgen radiation hazards. The possibilities of roentgen-ray injury are cited as well as the limitation of protection that can be expected.

RECIPIENT INTENSITIES OF STRAY RADIATION

It has been shown[3] that when apparatus such as the Army Field roentgen-ray equipment is used for horizontal roentgenoscopy, the distribution of stray radiation, above the table top, is essentially the same as with conventional roentgenoscopic equipment. Since the operator of Army equipment is required to wear a lead impregnated apron, it is only below this apparel that he could receive radiation in excess of that to which he might be subjected with conventional equipment.

There are three important components of radiation to be considered in the region below the lead impregnated apron: leakage of primary and stray radiation from within the tube housing itself; secondary radiation from the shutters and their housing, and secondary radiation from the patient. These have been discussed more fully in the preceding paper.[3] It is the function of the auxiliary lead impregnated shield (feature 15) to protect the knees, legs and feet of the operator from these three components. This shield in conjunction with the lower part of the lead impregnated apron serves in much the same way as do the metal side panels on a totally enclosed "heavy duty" roentgenoscopic table.

The data contained in Table 1 are representative values selected from extensive testings performed by the several observers. Measurements were made with the roentgen tube in the middle position of table width as well as in the far and near positions. The data here recorded are of maximum values in this respect. Moreover, they are based upon the outer limits of roent-

TABLE 1

IONIZATION MEASUREMENTS WITH THE STANDARD UNITED STATES ARMY FIELD TABLE UNIT

Roentgens per hour as measured at knee and foot positions for operator (apron not placed in position as it would be worn)

Observer	Glasser*	Picker†	Wintker‡	Present Authors
Size of phantom	25×25×25 cm.	25×25×25 cm.	20×31×21 cm.	20×31×21 cm.
Field at screen	25×25 cm.	25×25 cm.	25×25 cm.	20×20 cm.
Knee	0.048	—	0.023	0.020
Foot	0.048	0.036	0.008	0.020

* Values in this column are presented with the kind permission of Dr. Otto Glasser, Cleveland Clinic Foundation. The values otherwise tabulated were obtained subsequent to an improvement in the method of fixation of the auxiliary shield.

† Appreciation is expressed for the special interest by Mr. E. R. Goldfield and Mr. Tom Callaghan of the Picker X-ray Corporation in conducting independent testings from which this value was selected.

‡ First Lieutenant, Sanitary Corps, Department of Roentgenology, Army Medical School, Washington, D. C.

genoscopic factors—85 kv. (peak) and 5 ma. They are concerned with *continuous* exposures. It is estimated that, allowing for the exchange of patients, the marking and making of adjustments between exposures together with intermittent interruptions of common practice, actual energization of the equipment can be expected for approximately 25 per cent of the time. Thus two and one-half hours of continuous operation might be considered equivalent to a ten hour day of roentgenoscopic activity. It will be noted that if the exposure values given in the table were adjusted for a ten hour day (multiplying by the factor of 2.5) the summation values are well under the recognized tolerance dose. Similar low exposure intensities were found for the lighter weight unit.

DISCUSSION

The Subcommittee on Radiology* of the Committee on Surgery of the National Research Council, after hearing of the protection features, together with the analyses which have been made and seeing the equipment, have expressed themselves with the following resolution:

> Investigations have been made of the protection provided by the U. S. Army Field Apparatus. The Subcommittee on Radiology for the National Research Council is of the opinion that the protection is adequate if accessory equipment furnished is used according to instructions.

It has been pointed out that precautions have been taken to protect the operator's chest, trunk and lower extremities against exposures which many roentgenologists accept daily upon their arms and shoulders with complete unconcern. These exposures of the shoulders and arms may be several times the internationally accepted tolerance dose. Is it to be concluded that the standard includes a factor of safety sufficiently large so far as exposure to a limited portion of the body is concerned, to make us accept such exposures as safe? Geneticists have presented evidence which indicates maleffects to quantities of radiation considerably smaller than the tolerance dose, at least when exposing the reproductive organs. Yet so far as can be judged from the official statement of the tolerance dose, any portion of the body, large or small, requires the same protection as the whole body. For various reasons (e.g., pension claims, morale, etc.), the Army is compelled to adhere as closely as possible to official standards. This leads to complications where the standards are equivocal. In anticipation of future problems as far as our Government is concerned and considering the interest which has been manifested by the public as a whole, it would seem that radiologists and radiation physicists should strive for a more detailed specification of the tolerance dose; a definition of it with respect to exposure of the trunk, with respect to exposures of the extremities alone, or the whole body.

* The Subcommittee consisted of the following: Dr. A. C. Christie (Chairman), Dr. B. R. Kirklin, Dr. U. V. Portmann, Dr. W. E. Chamberlain and Dr. E. P. Pendergrass.

SUMMARY

1. A description of the protective features incorporated into both types of Army roentgenoscopic equipment is presented.

2. Sixteen features of design concerned with protection are described.

3. Ionization measurements of exposure concerned with parts of the body protected by a lead apron and the auxiliary lead protective shield are tabulated.

4. The resolution of the Subcommittee of Radiology of the National Research Council, expressing satisfaction with this equipment, is cited.

5. It is suggested that a more adequate definition of the tolerance dose be expressed with consideration of exposure of the trunk portions of the body, the extremities alone or the whole body.

REFERENCES

1. DE LORIMIER, A. A. Wartime military roentgenology. *Radiology*, 1941, *36*, 391–403.
2. DE LORIMIER, A. A. Foreign body localization as provided with the United States Army table

unit. Am. J. Roentgenol. & Rad. Therapy, 1942, *47*, 307–313.
3. White, T. N., Cowie, D. B., and de Lorimier, A. A. Radiation hazards during roentgenoscopy. Am. J. Roentgenol. & Rad. Therapy, May, 1943, *49*, 639–652.

Discussion of Papers by White, Cowie and de Lorimier

Dr. Robert B. Taft, Charleston, S. C. Two years ago, before this Society, I had a little paper on stray radiation. Dr. Glasser, in the discussion of that paper, said I had presented absolutely nothing new except colored lantern slides, but he went on to say that it was a good paper because all papers on stray radiation are good papers as they make us more conscious of the dangers that we are running if we are not careful.

Colonel de Lorimier has presented some new material here: first of all, very careful tests all around roentgen tubes in operation, which, as far as I know, have not been accurately recorded in the past. He has not only done that, but he has given us a large amount of information on the sources of secondary radiation which one gets around a fluoroscope. I have gone over his figures very carefully and studied both of these papers, and in my opinion this table is a perfectly safe apparatus with which to work under any ordinary circumstances.

I definitely believe that any man doing roentgenoscopy ought to wear an apron. I think it is a simple form of protection which means more than anything that can be done to the machine. I believe a man is taking a very foolish chance not to wear an apron. I do, however, know of lots of good lead rubber aprons that are hanging up on a peg on a wall while the radiologist is doing his roentgenoscopic work. I am glad to say that the pendulum has swung in the right direction in regard to roentgen-ray protection and I am delighted to see papers of this kind presented. There is only one thing wrong about a presentation of this kind. It does not get to the right men. The members of the American Roentgen Ray Society know something about roentgen-ray protection. Where these papers ought to be given is back home in our local medical societies where men are fooling with small roentgen machines without knowing what they are doing.

I have only to quote briefly a paper of our esteemed colleague, Dr. Pfahler, from the *American Dental Journal* a number of years ago. Very briefly, if I remember the story, a physician and a dentist went out shooting. There was a minor accident. One of them got a small shot in his finger. They came back and proceeded to remove it fluoroscopically under the dental roentgenographic machine, as a result of which both of them had to have so many fingers amputated that the dentist had to quit doing dentistry and the surgeon had to give up surgery.

Those things go on happening and I know of many cases that have happened after Dr. Pfahler wrote that paper.

I think the manufacturers have done an excellent job in making tubes shock proof. They have done a reasonably good job in making tubes ray proof. They have, however, as I said, not made the tubes fool proof and I do not know of any roentgen machine which will not give a dangerous dose of radiation to a man who stands in the beam of it.

Major Theodore S. West, M.C., U. S. Army. Colonel de Lorimier and his associates have made a great contribution in this investigation of roentgen-ray hazards. I have been greatly interested in the matter of roentgen-ray protection for many years, and it is my belief that many of the younger roentgenologists do not fully appreciate the hidden dangers of the agent with which they work, and that they are inclined to expose themselves to an unsafe amount of radiation.

Those of us who had the advantage of Professor Shearer's teachings appreciate the dangers to ourselves and to our patients, and have a wholesome fear of roentgen rays, which does not seem to be shared by the younger men. Indeed, some of the older roentgenologists seem to be getting careless of themselves—if not of their patients.

I heartily agree with Dr. Taft that this work of Colonel de Lorimier's should be broadcast to the medical profession at large, and not be presented only to roentgenologists who are at least supposed to realize the dangers. Roentgenologic apparatus is now being purchased and used by an increasing number of physicians who have not had adequate training or instruction, and who do not appreciate the dangers.

Advertisements for apparatus seem rather to emphasize the innocuousness of the roentgen ray. I recall a picture in one of the recent journals showing the patient cozily snuggled in bed, the mobile roentgen unit in position, the kindly doc-

tor along side, and the beautiful nurse with her toe on the foot switch. No protective apron or gloves, not even a reasonable distance protecting anyone from the scattered radiation.

I recently visited the roentgen department of a fairly large hospital in which the control stand was in the same room with the roentgen table. No protective booth, not even a protective screen to shield the operator.

I have recently seen several cases of severe roentgen burns resulting from the use of the fluoroscope for guidance in setting fractures or extracting foreign bodies. The victims, in four of these cases, were physicians who "didn't realize the danger."

It seems to me that it is the responsibility of the radiological societies to make an attempt to educate the profession at large on this matter. Perhaps a brochure on the subject could be published by the combined societies, and, in cooperation with the manufacturers of roentgen-ray equipment, given to every purchaser of a roentgen-ray apparatus. This may be a big order, but I believe it is our job to see that some such work is done.

Dr. Lauriston S. Taylor, Washington, D. C. One of my main jobs for many years has been the study of roentgen-ray protection, and this paper dealing with radiation hazards during roentgenoscopy has been particularly gratifying to me because the authors have attacked a difficult protection problem and not become panicky in the process. I am probably one of the strongest believers in protection, yet I feel that there has been a tendency to become panicky and to over-protect to the point where the equipment is no longer usable or where the medical procedures cannot be carried out adequately. Perfect protection can, in my opinion, be obtained only by never turning on the roentgen tube.

I was particularly glad also to see the point brought out indicating the importance of scattered radiation from the patient's body. Many elaborate roentgen-ray protective installations have centered about the radiation which emanates from the tube, paying practically no attention to that which comes from the patient's body and from nearby metal surroundings, table tops and so on. As was very clearly pointed out a number of times, the bulk of the radiation does come from the patient and not from the tube proper.

Mr. Singer, in our laboratory, has been studying a number of pieces of new equipment for the Army. These have been what I believe Colonel de Lorimier describes as the heavy duty type of equipment. It has been our finding, in practically every case, that if you examine the radiation which comes from the roentgen tube, you will find evidence of leakage and your first reaction is to become very much upset and to tell the manufacturer he has to put more lead around the tube. However, in practically every case—I believe in every case—it is found that the simple sheet steel barriers which are put there for the purpose of electrical protection, or for mechanical strength are quite adequate to completely cut off the remainder of the radiation which does leak out of these tube housings. When I say completely cut off, I mean it reduces it to a level beyond which it would be foolish to go any further, because you are operating in an atmosphere of stray radiation no matter what you may do otherwise.

This matter of protection about the roentgen tube is viewed in this paper for the first time that I know of, in its proper light.

There is one other point which was considered in the course of the studies at Walter Reed Hospital. I have discussed these at considerable length with Dr. White and I am not sure whether or not they are going to mention this in the paper. In addition to the broad outlines which have been presented here, they have also studied specific small regions where more intense radiation might be obtained. For example the radiologist must keep his hand on the shutter controls for a considerable period of time. That is behind the barrier, or at one side of the barrier, I believe, and it is quite conceivable that stray radiation from the roentgen tube might expose that particular location to much stronger radiation than would be encountered at any of the normal positions of the body. In this particular case, as an example, they carried the investigation through and found that the radiation was or could be reduced to a safe level and then pronounced the equipment safe.

The authors are to be very strongly congratulated on the thoroughness with which this piece of work has been carried out.

Colonel de Lorimier (closing). I wish to thank the discussants and in particular Major West and also Dr. Taylor for their kind remarks and to pay a tribute to Dr. Scheele and Mr. Cowie and Dr. White for the excellent work that they are doing in going around the coun-

try and conducting testings of the same sort with respect to the various roentgenoscopic rooms. Dr. Taylor and Dr. Singer are concentrating on this matter of radiation hazards in their testing of field roentgen-ray equipment.

I wish to make one more remark. That has to do with a plea mentioned in the latter part of our second paper, in which I tried to emphasize the amount of radiation that is received by the shoulders and arms of the roentgenoscopist regardless of the type of equipment which he is using. In anticipation of future problems—I mean pension claims as far as our government is concerned—and considering the interest which has been manifested by the public as a whole, it would seem that radiologists and radiation-physicists should strive for a more detailed specification of the tolerance dose, a definition of it with respect to exposure to the trunk, with respect to exposure to the extremities alone, or with respect to exposure of the whole body.

STUDIES ON THE INDIRECT EFFECT OF ROENTGEN RAYS IN SINGLE AND PARABIOTIC MICE*

By W. A. BARNES, M.D., *and* O. B. FURTH, M.D.
From the Department of Pathology, Cornell University Medical College,
NEW YORK, NEW YORK
and
The Marine Biological Laboratories
WOODS HOLE, MASSACHUSETTS

A VAST literature has accumulated on the effect of irradiation on normal and malignant tissues since Heineke[13] in 1904 described the destructive changes occurring in lymph nodes, spleen, and bone marrow following irradiation by roentgen rays. He noted the occurrence of leukopenia and suggested that the diminution in circulating lymphocytes was referable to selective destruction of lymphoid tissue by roentgen rays. His observations have been confirmed by numerous workers,[10,21] and little of fundamental importance has been added. Opinions concerning the mechanism of the action of roentgen rays on living tissue can be considered under three headings: (a) direct effect on cells, (b) indirect effect, local and general; (c) combined direct and indirect effect.

Direct Effect. Numerous experimental studies have indicated that the most important action of roentgen rays on living tissue is the direct effect on cells, although there is no agreement concerning the mechanism.[8,9,33,34,36] This effect will not be considered in detail.

Indirect Local Effect. Many investigators are of the opinion that only by interaction of cells and tissue fluids surrounding the irradiated cells is the injurious effect of irradiation accomplished, e.g., production of secondary rays,[8,9,20] damage to endothelial linings of capillaries followed by proliferative changes,[29] alterations in permeability of cell membranes, or in the acid base equilibrium,[26] changes in the concentration of radio-ions,[11] etc.

Indirect General Effect. Many investigators believe that roentgen rays produce an effect in organisms even in parts not directly exposed to the rays.[cf.34] This indirect general effect has been attributed (*a*) to circulation of toxic substances[40,47] or more specifically to products of disintegration of proteins named necrohormones;[7] (*b*) to the action on the autonomic nervous sytem;[23,32] (*c*) to action on organs of internal secretion;[cf.46,19] (*d*) to changes in the chemical composition of blood;[16,19] (*e*) to changes in electrolytes,[35] etc.

Since the indirect general effect of roentgen rays is doubted by some investigators, and few experimental studies have been reported, we have reinvestigated the character and magnitude of changes produced in tissues of single and parabiotic animals exposed directly to roentgen rays or protected from them while other portions of the body were subjected to irradiation. A few investigators have studied the effect of roentgen rays on parabiotic animals, but these results have not been concordant. We shall describe first the changes in single animals. Observations on the effect of irradiation on the blood and blood forming tissues of parabiotic mice will then be presented.

Changes in the bone marrow of animals following exposure to roentgen rays have been described in numerous reports.[2,13,15,22,37,38,39,42,43,45] As early as 1905, Aubertin and Beaujard[3] described the unexposed bone marrow of irradiated rabbits as red and hyperplastic. Recently while our investigations were in progress, Hsü and Ma[15] studied changes in the exposed and unexposed bone marrow, spleen, and lymph nodes of rats whose right hind limbs were irradiated with a daily dose of 125 r for a total of 1,000, 2,500 or 5,000 r. Changes in the exposed and non-exposed bone marrow were similar, i.e., increase of fat cells, hyperplasia of erythrocytes and hypoplasia of myeloid cells. The changes in

* This investigation has been supported by the International Cancer Research Foundation, The Lady Tata Memorial Trust, and The Anna Fuller Fund.

parabiotic and 1 of the control mice were irradiated over the entire body, while the other parabiont and single mouse were completely shielded from the rays. In one experiment (Twins No. 294 and No. 298 irradiated with 3,200 r) the mice were irradiated while under nembutal anesthesia and were not tied. In each experiment the number of leukocytes of parabionts and of single control mice was determined at two to three day intervals several times before, and from two to fifty days after irradiation. Blood was obtained from the tail vein, and specially designed small diluting pipettes were used permitting the accurate withdrawal of a small quantity of blood (approximately 0.04 cc.). Differential counts were made on smears stained with Wright's and Giemsa's solutions. Two hundred cells were counted except when the total number of leukocytes per cubic millimeter was less than 800 when fewer cells were counted or differential counts were omitted.

The physical factors of irradiation of parabiotic mice were as follows: 200 kv., 15 ma., 3 mm. Al, 25 cm., 320 r per minute. In Twins No. 149, 195, 300, 301, 302, 303 the physical factors were 198 kv., 25 ma., 68 cm., 94 r per minute. The mice died or were killed at intervals from one to fifty days following exposure. If one parabiont died, its twin and control mice were immediately killed.

To observe indirect effects of irradiation sections were taken from organs most distant from the site of irradiation, e.g., bone marrow from the left femur of the left mouse if the right member of a parabiotic pair was irradiated. Tissues were fixed in Bouin's solution and sections stained with hematoxylin and eosin.

OBSERVATIONS ON SINGLE ANIMALS

Bone Marrow

Mice. 800 r. Seventeen mice were exposed to 800 r over the entire body except the right leg. One or 2 mice were killed on each of the days after irradiation indicated below, together with a total of 6 non-irradiated control mice of the same stock and age. Reduction in the size of the spleen and lymphoid tissue of the irradiated mice was noted as recorded by other investigators. The histological changes in the irradiated and non-irradiated femoral marrow are indicated in Table 1.

The direct effects on bone marrow of irradiation with 800 r may be summarized as follows: hyperemia beginning within twenty-four hours and continuing for about ten days; decrease in the total number of hematopoietic cells, most conspicuous from the third to the fifth days; regeneration beginning on the sixth or seventh day, approaching completion by the eleventh or twelfth day, and characterized by increased number of megakaryocytes from the tenth to the twelfth days.

The indirect effects were as follows: slight hyperemia, present during the first two days; no reduction in the total number of nucleated cells; slight increase of polymorphonuclear leukocytes during the first two days, and slight myeloid hyperplasia with increased numbers of megakaryocytes from the ninth to the twelfth days.

2,000 r. In attempts to produce more conspicuous changes in non-exposed bone marrow of irradiated animals, 6 mice were irradiated with a large single dose (2,000 r) of roentgen rays over the entire body except one leg. The changes in the femoral marrow after irradiation were as follows:

One Day. Direct Effect. There is conspicuous dilatation of vessels with moderate decrease in total number of hematopoietic cells, but metamyelocytes, polymorphonuclears and megakaryocytes are numerous. *Indirect Effect.* There is slight dilatation of vessels, but no decrease in the number of cells.

Three Days. Direct Effect. Vascular dilatation is extreme and very few hematopoietic cells persist. There are several megakaryocytes. *Indirect Effect.* As in the preceding mouse.

Four Days. Direct Effect. As at three days but with only occasional megakaryocytes. *Indirect Effect.* Slightly more capillary dilatation than in the preceding mouse.

Five Days. Direct Effect. Almost no hematopoietic elements remain. *Indirect Effect.* As on the fourth day after irradiation.

Seven Days. Direct Effect. Conspicuous vascular dilatation with several foci of regenerating cells among which are numerous metamyelocytes. *Indirect Effect.* Apparently normal bone marrow with slightly increased number of megakaryocytes and erythrogenic foci.

the unexposed marrow did not vary conspicuously with the quantity of radiation and were notably less than in the directly irradiated marrow. In the spleen directly irradiated, the lymph follicles were reduced in size, there were islands of erythroblasts in the red pulp and the number of phagocytes increased with increase in the dose of roentgen rays. In unexposed lymph nodes there was reduction in the number and size of the lymph follicles in the cortex, increase in size of the sinusoids in the medulla, and increase of plasma cells. The authors consider the changes in the spleen, lymph nodes and non-irradiated marrow as "compensatory hyperplasia." Akaiwa and Takeshima[1] studied the effect of irradiation on popliteal lymph nodes of rabbits, of which one knee was exposed to $\frac{1}{3}$, $\frac{1}{2}$, 1 or 2 "S. U. D.," and the other used as "control." Sections were made at from thirty minutes to three weeks after irradiation. As early as one hour after exposure to $\frac{1}{3}$ "S. U. D.," disintegration of lymphocytes in the lymph follicles began, reaching a maximum in from two to six hours. From this time on, marked phagocytosis was noted, the monocytes taking up the chromatin particles of the decomposed nuclei. This activity almost ceased after forty-eight hours. Regeneration of the lymphoid tissue then occurred and by the seventh day the node was normal except for slight increase in connective tissue. In the non-irradiated lymph node there was slight increase in the number of mitotic figures after one hour. At two hours there was disintegration of lymphocytes. Phagocytosis was present at twenty-four hours and fragments of cells were present to the tenth day. There was return to normal only after two weeks. Similar changes occurred with larger doses except that the end-result was fibrosis of both irradiated and non-irradiated lymph nodes.

There have been numerous studies concerning the effect of irradiation on cells of the circulating blood of single animals. It is certain that leukocytes and particularly lymphocytes are profoundly damaged by roentgen rays[5,17,18,28,41,44] although opinions differ as to the mechanism of leukopenia.

A few investigators have studied the effect of roentgen rays in parabiotic animals. The results have not been uniform.

While Zacherl[46] and Zwerg,[47] working with parabiotic rats, found leukopenia in both the irradiated and shielded animal, Woenckhaus[44] described leukopenia in the irradiated parabiotic rat and leukocytosis in the shielded parabiont. Behne[4] found leukopenia in both the irradiated and shielded parabiotic guinea pig twenty-four hours after irradiation; and whereas the irradiated animal showed progressive leukopenia until its death five or six days after irradiation, the shielded parabiont showed an "enormous" leukocytosis two days after irradiation.

The contradictory results of these earlier studies on parabiotic animals can be explained as follows: The number of parabiotic pairs used is often not stated; in many instances the results in one pair only are analyzed. The number of leukocytes of small laboratory animals varies greatly under physiological conditions, and only a very marked drop or rise, if consistently found, should be considered significant. The quantities of roentgen rays used are frequently not stated, reference being made to small, medium or lethal doses. The investigations were concerned with changes in blood counts without examination of the blood forming organs, and the relation of different doses of roentgen rays to the blood changes produced was not studied.

MATERIALS AND METHODS

The animals used came from several stocks of mice inbred in this laboratory for many years. In each experiment mice of the same stock, of the same age, and in many cases litter mates, were used. In animals in which only a part of the body was irradiated, the remainder was protected by from 3 to 6 mm. of lead and adequate precautions were taken against scattered rays.

For experiments on single animals the factors of irradiation were usually 200 kv., 15 ma., 25 cm., 3 mm. Al, and 320 r per minute. In several experiments the factors were 200 kv., 15 ma., 50 cm., 1 mm. Cu—1 mm. Al, and 50 r per minute.

In the experiments on parabiotic twins, 2 of 4 mice in each group were joined in parabiosis by the method of Sauerbruch, as modified by Bunster and Meyer[6] with changes previously described.[12] Two to four weeks after operation all 4 mice were tied to a wire frame, and 1 of the

TABLE I

CHANGES IN EXPOSED AND NON-EXPOSED BONE MARROW OF MICE IRRADIATED WITH 800 r

Irradiation		Changes in Bone Marrow			
Days after	Type	Capillary Dilatation	Total Number of Cells	Polymorphonuclears	Megakaryocytes
1	Direct Indirect	++ +	<+ o	++ +	o o
2	Direct Indirect	+++ +	<++ o	++ +	o o
3	Direct Indirect	++++ ±	<++++ o	<++++ o	<++ o
4	Direct Indirect	++++ o	++++ o	++++ o	<+++ o
5	Direct Indirect	++++ o	<++++ o	<++++ o	<++++ o
6	Direct Indirect	++++ o	<+++ o	<++++ o	<++++ o
7	Direct Indirect	+++ o	<+++ o	<++++ o	<++++ o
8	Direct Indirect	+++ o	<++ o	<++++ o	<+++ o
9	Direct Indirect	+++ o	<++ +	<+++ ±	<+++ ++
10	Direct Indirect	+ o	<+ +	<+ ±	o ++
11	Direct Indirect	o o	+ +	o ±	+ ++
12	Direct Indirect	o o	+ +	o o	± +

o = no effect.
± = questionable.
+ = slight.
++ = moderate.
+++ = extensive.
++++ = very extensive.
< = decrease.

6,000 r. In further attempts to produce more conspicuous changes in non-exposed bone marrow of irradiated animals, 9 mice were exposed to 6,000 r over the upper or the lower half of the body. Three normal mice were studied as controls. The changes in marrow exposed to and shielded from the roentgen rays were as follows:

One Day. Direct Effect. There is moderate dilatation of capillaries, and conspicuous decrease in the number of hematopoietic cells with slight increase in polymorphonuclears. Slight fragmentation of nuclei is evident. *Indirect Effect.* There is slight hyperemia and a questionable slight decrease in the total number of hematopoietic elements. Multilobed polymorphonuclear leukocytes are increased in number.

Three Days. Direct Effect. There is very con-

spicuous dilatation of capillaries, and almost complete aplasia. A few megakaryocytes persist. *Indirect Effect.* There is very slight hyperemia. In 1 mouse there is questionable slight decrease in the total number of hematopoietic cells; in 2 other mice there is no obvious deviation from normal.

Six Days. Direct Effect. There is very conspicuous capillary dilatation and almost complete absence of hematopoietic cells of the marrow. *Indirect Effect.* No abnormalities are noted.

Rabbits. 1,500 r. The effect on bone marrow of irradiation with 1,500 r of the upper two-fifths of the bodies of rabbits is shown in Table II. In the marrow of the humerus exposed directly to roentgen rays pyknosis was noted as early as two and one-half hours after irradiation with subsequent marked destructive changes. In the femoral marrow not directly irradiated, there was questionable hyperemia and pyknosis after two and one-half hours; after six hours pyknosis was more evident. Hyperemia increased until the second day when increased numbers of polymorphonuclear leukocytes were noted in the non-exposed marrow.

Comment. The effects produced in exposed and non-exposed bone marrow of mice receiving 800, 2,000, or 6,000 r to the entire body except one leg varied but little qualitatively. The larger the dose, the earlier noted was the decrease of hematopoietic cells in the directly irradiated marrow. There was capillary dilatation in the unexposed marrow from three to five days after irradiation, but no decrease in the number of hematopoietic cells except perhaps one to three days after 6,000 r. These experiments show that in mice, after a single exposure (with one leg shielded) to as much as 6,000 r, there are no conspicuous destructive effects in the non-exposed marrow after from three to five days. Six hours following irradiation with 1,400 r of two-fifths of the bodies of rabbits, pyknosis was noted in non-exposed bone marrow with no destructive changes thereafter.

TABLE II

EFFECT OF IRRADIATION OF UPPER TWO-FIFTHS OF BODIES OF RABBITS WITH 1,500 r

Rabbit Number	Time killed after irradiation	Thymus					Cervical Node					Marrow of Humerus					Spleen					Mesenteric Node					Popliteal Node					Marrow of Femur				
		Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Hyperemia	Total cells	Pyknosis	Fragmentation	Polymorphonuclears	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Fibrosis	Hyperemia	Lymphocytes	Pyknosis	Fragmentation	Mononuclears	Polymorphonuclears	Hyperemia	Total cells	Pyknosis	Fragmentation	Polymorphonuclears
1	2½ hr.	+	N	o	o	N	o	N	o	o	N	+	o	N	o	o	+	o	N	o	o	N	+	o	o	N	o	o	N	+	o	+	o	o	N
2	6 hr.	o	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
3	12 hr.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
4	1 da.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
5	2 da.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
6	4 da.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
7	8 da.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N
8	8 da.	+	N	o	o	N	+	N	o	o	N	+	+	N	+	o	+	o	N	+	o	N	+	o	o	N	+	o	N	o	+	N	+	o	N

N = normal o = none ± = questionable + = slight 2+ = moderate 3+ = extensive 4+ = very extensive < = decrease

Lymph Nodes

Lymphocytes have long been recognized as the cells most susceptible to direct ef-

fect of roentgen rays and, as the following observations show, they are also susceptible to an indirect effect.

Lymph nodes from the neck and abdomen of 9 mice which had received 6,000 r to either the upper or lower half of the body were examined. The significant changes several hours after irradiation, slight in the shielded and marked in the exposed nodes, were as follows: pyknosis and fragmentation of the nuclei of lymphocytes, especially in the germinal centers after a few hours; hyperplasia of mononuclears with phagocytosis of cell fragments after twenty-four hours and removal of cellular débris during the next two days. After three days, the number of lymphocytes remained reduced in the exposed nodes.

Two adult rats were subjected to biopsy of right inguinal and axillary lymph nodes. The following day 6,000 r was administered to the upper half of the body of 1 rat and to the lower half of the body of the other, and eight hours later the left inguinal and axillary nodes were removed. The nodes directly exposed to roentgen rays showed extreme fragmentation of the nuclei of lymphocytes and many of the fragments were within mononuclear cells. The shielded nodes likewise contained intracellular and extracellular nuclear fragments, although conspicuously fewer than in the nodes exposed to direct irradiation.

As early as two and one-half hours after irradiation with 1,500 r of the upper two-fifths of the bodies of rabbits there was pyknosis and fragmentation in non-exposed spleens and mesenteric lymph nodes. Changes in non-exposed popliteal nodes were less conspicuous (Table II).

In 2 rabbits exposure of a leg to 2,560 or 3,200 r was followed in six hours by slight but definite pyknosis and fragmentation of nuclei in non-exposed popliteal nodes (Table III). Eight hours after the lower half of the body was irradiated with 3,200 r similar but more conspicuous changes occurred in shielded cervical, axillary and submandibular lymph nodes. The lymph nodes directly exposed to roentgen rays were extensively damaged. Although as much as 7,280 r was given to the ear of a rabbit pyknosis or fragmentation of nuclei was not observed seven hours later in an iliac lymph node (Table III).

TABLE III

EFFECT OF DIRECT AND INDIRECT IRRADIATION ON LYMPH NODES OF RABBITS

Part Irradiated	Dose of Roentgen Rays	Time of Examination after Irradiation	Fragmentation and Pyknosis in Lymph Node	
			Exposed	Shielded
	(r)	(hr.)		
Left leg	2560	6	+++	±
23 days later				
Lower half of body	3200	8	+++	++
Left leg	3000	6	+++	++±
Ear	7280	7	—	○

Scattered radiation might be held responsible for the changes occurring in non-exposed lymph nodes in animals as small as mice but the experiments on rats and rabbits eliminate this possible criticism.

Specificity of Changes in Shielded Organs of Irradiated Animals

Are the changes—hyperemia, slight increase of polymorphonuclear leukocytes in the bone marrow, and fragmentation and pyknosis of nuclei in the lymph nodes—specific indirect effects of irradiation, or non-specific? A study of the literature indicates

that similar degenerative changes can be produced by burns,[30, 43] heat, cold, electric current, and many chemicals and that there is little if any difference between the histological changes following irradiation and those induced by other means[cf. 25] A few experiments of our own confirm this observation.

Mice under nembutal anesthesia were burned by actual cautery over the abdomen and chest. They were killed from six to twenty-four hours later. The lymph nodes and bone marrow of these mice showed changes that were indistinguishable from those observed in these organs following indirect irradiation. The lymph nodes of 2 mice dying of iodoacetic acid poisoning also showed similar changes.

TABLE IV

CHANGES IN THE BLOOD FORMING ORGANS OF PARABIOTIC MICE FOLLOWING IRRADIATION WITH 800 r OF ONE PARABIONT

No. of Twin	Mouse Examined	Days after Irradiation Killed or Died	Macroscopic		Microscopic				
			Size		Bone marrow		Spleen		
			Lymph nodes reduced	Spleen (mm.)	Hyperemia	Reduction in No. of cells	Hyperemia	Reduction in No. of cells	Erythrogenesis
300	X single	1	+	13×4	++	++	+++	+	o
	X twin		o	12×3	+++	+	+	++	o
	C twin		o	12×3	+	o	o	o	o
	C single		+	18×5	o	o	o	o	+++
237	X single	3	++	11×2	++++	++++	+++	++	o
	X twin		+	12×2	++++	+++	+++	++	o
	C twin		o	20×4	+	o	o	+	+++
	C single		o	15×3	o	o	o	o	o
303	X single	3	+	11×3	++++	++++	+++	++	o
	X twin		+	12×3	++++	+++	o	o	+
	C twin		o	10×3	++	+	o	o	+
	C single		o	13×4	o	o	+	o	o
302	X single	5	+	12×3	++++	++++	++	++	o
	X twin		o	10×3	++++	++++	+	o	o
	C twin		o	18×4	o	o	+	o	++
	C single		o	16×4	o	o	o	o	o
238	X single	7	++	8×1	++++	++++	+++	+++	o
	X twin		+	10×2	+++	+++	++	++	+++
	C twin		o	11×3	++	o	o	o	++
	C single		o	15×5	o	o	o	o	+++
195	X single	10	o	10×2	+++	++++	+	o	o
	X twin		o	13×3	++	++	o	o	o
	C twin		o	11×2	+	+	+	o	o
	C single		o	15×5	o	o	++	o	o
301	X single	11	o	20×5	+	++	o	o	+++
	X twin		o	14×3	++	+++	o	o	+++
	C twin		o	20×4	o	o	o	o	++
	C single		o	18×4	o	o	o	o	+

X = irradiated.
C = non-irradiated.

OBSERVATIONS ON PARABIOTIC MICE

Effect of Varying Doses of Roentgen Rays on the Blood Forming Organs

800 r. The blood forming organs of 7 pairs of parabiotic mice were examined from one to eleven days after irradiation with 800 r of 1 member of each pair. At the same time the organs of 1 irradiated and 1 non-irradiated single control mouse were examined. Changes in spleen, lymph nodes and bone marrow are summarized in Table IV.

twin is suggested by increased erythropoiesis in the spleen of 2 non-irradiated parabionts.

3,200 r. In order to determine whether larger doses of roentgen rays would produce significant effects in the non-irradiated member of a parabiotic pair, 1 member of each of 2 parabiotic twins was exposed to 3,200 r. One single mouse was similarly irradiated at the same time. One set of twins was examined four days and the other set six days after irradiation. The outstanding findings are shown in Table V.

TABLE V

CHANGES IN THE BLOOD FORMING ORGANS OF PARABIOTIC MICE AFTER IRRADIATION OF ONE PARABIONT WITH 3,200 r

No. of Twin	Mouse Examined	Days after Irradiation Killed or Died	Bone Marrow		Spleen	
			Hyperemia	Reduction in No. of cells	Erythropoiesis	Reduction in No. of cells
299	X twin	4	++++	++++	0	++++
	C twin		+	0	+++	0
298	X single	6	+++	++++	0	++++
	X twin		+++	++++	0	+++
	C twin		+	0	0	+
	C single		±	0	±	0

X = irradiated. C = non-irradiated.

This experiment shows that following irradiation with 800 r the pathological changes occurring in the blood forming tissues of irradiated mice in parabiosis with non-irradiated mice are slightly less than those occurring in single mice similarly irradiated. There is slightly less reduction in the total number of hematopoietic cells in the marrow in the irrradiated parabiont. Hyperemia and decreased cellularity in the spleen are less conspicuous in the irradiated parabiont than in the irradiated single control. In the non-irradiated parabiont evidence of damage to hematopoietic tissue is minimal. While there may be slight hyperemia in the bone marrow, decrease in the number of hematopoietic cells does not occur. There are no destructive changes in the spleen; however, that the non-irradiated parabiont is affected by irradiation of its

There was severe damage to the spleen and bone marrow of the single irradiated mouse and of the irradiated twins; whereas, in the non-irradiated parabionts there was only slight hyperemia of the bone marrow, and, in 1, conspicuous erythropoiesis in the spleen.

6,000 r. In a third group of parabiotic twins, the early changes produced by a very large dose of roentgen rays were studied. Six thousand roentgens were given to 1 parabiont with the other shielded. One set was killed six hours and another seventy-two hours after irradiation. The results are shown in Table VI.

Seven hours after irradiation the spleen of the irradiated parabiont showed marked hyperemia, extensive fragmentation of nuclei of the lymphoid cells, an increase of polymorphonuclear leukocytes, with a definite decrease of

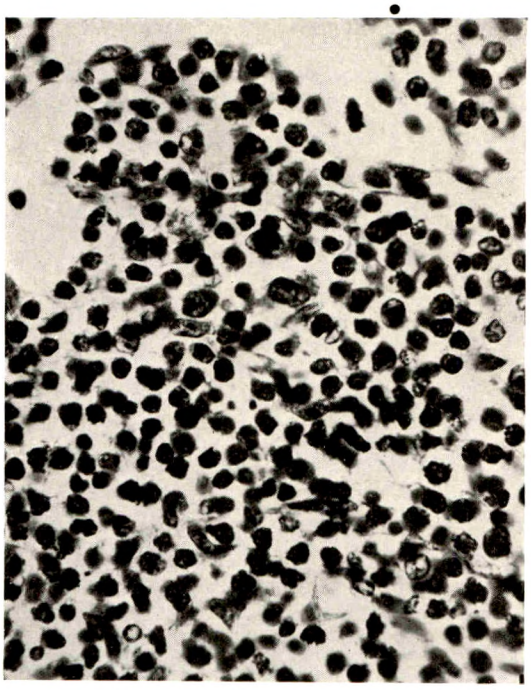


FIG. 1. The tissues illustrated in Figures 1, 2, 3 and 4 were fixed in Bouin's solution. The sections were stained with hematoxylin and eosin. Magnification are approximately 750×.

Cervical lymph node of control mouse.

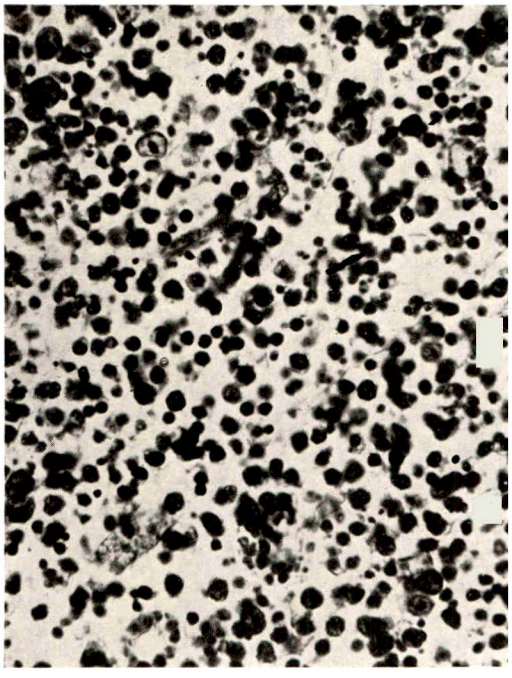


FIG. 2. Cervical lymph node of mouse seven hou after irradiation of upper third of body wi 3,200 r. Conspicuous pyknosis and fragmentati are evident.

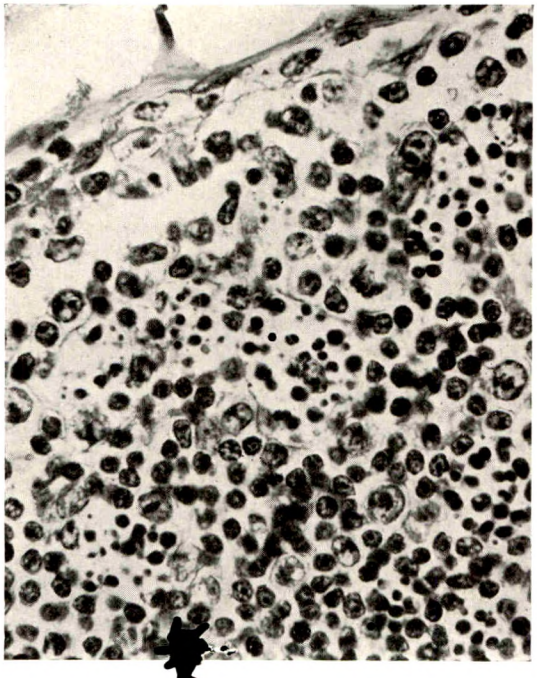


Fig. 3

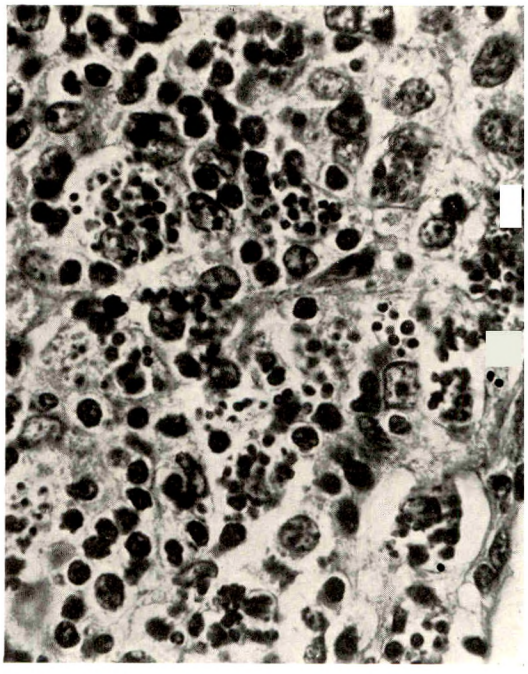


Fig. 4

FIG. 3 and 4. Cervical lymph nodes of mice seven hours after irradiation of lower third of body with 7,0 r (Fig. 3) and 3,200 r (Fig. 4). There is fragmentation of lymphoid cells with phagocytosis by mon nuclear cells.

lymphoid elements. Fragmentation of nuclei was also marked in thymus and lymph nodes and only slight, but definite, in the bone marrow. The non-irradiated parabiont showed similar lesions, but to a lesser degree. In the bone marrow the only change was an increase of polymorphonuclear leukocytes.

In the parabionts examined seventy-two hours after irradiation the irradiated member showed marked hyperemia of lymph nodes and conspicuous decrease of cellular elements of bone marrow, while the nonirradiated parabiont showed an increase of polymorphonuclear cells in the bone marrow.

as the result of injury to hematopoietic organs, by Helber and Linser[14] as the result of direct injury to circulating blood cells and secondary changes in the blood forming organs due to circulating toxic substances.

Single Mice

It seemed desirable to establish the effect of varying doses of roentgen rays on the leukocyte counts of single mice so that the degree of change in the leukocyte levels of non-exposed members of irradiated parabiotic twins could be correlated with the dose required to produce similar changes in single mice.

TABLE VI

CHANGES IN THE BLOOD FORMING ORGANS AND THYMUS OF PARABIOTIC MICE AFTER IRRADIATION OF ONE PARABIONT WITH 6,000 r

No. of Twin	Mouse Examined	Hours after Irradiation Killed or Died	Thymus		Lymph Node			Spleen				Bone Marrow			
			Hyperemia	Fragmentation	Reduction in No. of cells	Fragmentation	Pyknosis	Hyperemia	Reduction in No. of cells	Fragmentation	Polymorphonuclears	Hyperemia	Reduction in No. of cells	Polymorphonuclears	Fragmentation
289	X twin	7	o	4+	+	3+	3+	2+–3+	+–2+	4+	4+	2+	o	+–2+	+–2+
	C twin		±	3+–4+	o	3+–4+	+	2+	+	2+–3+	3+	+	o	2+	o
288	X twin	72	o	o	3+	o						4+	4+	o	o
	C twin		o	o	±	±	o		Not examined			o	o	2+	o

X = irradiated.
C = non-irradiated

Comment. The changes occurring in the blood forming organs of a parabiont directly exposed to 800, 3,200 or 6,000 r are similar but quantitatively less than those occurring in a single mouse similarly irradiated. After irradiation of its twin with 800 or 3,200 r the non-irradiated parabiont shows no destructive changes in the blood forming organs one to eleven days later. However, seven hours after its twin received 6,000 r the non-irradiated parabiont showed pyknosis and fragmentation of nuclei of lymphoid cells. In spite of the initial damage the non-irradiated mouse recovered almost completely within three days, whereas the irradiated twin shows persistent damage consisting of aplasia of bone marrow and marked decrease of cellular elements of spleen and lymph nodes.

EFFECT OF VARYING DOSES OF ROENTGEN RAYS ON THE NUMBER OF LEUKOCYTES IN THE BLOOD OF SINGLE AND PARABIOTIC MICE

Marked decrease of leukocytes in circulating blood was explained by Heineke[13]

Thirty-seven single mice were exposed over the entire body to doses of roentgen rays varying from 100 to 1,000 r. Leukocyte counts were made on the first, third, sixth, tenth, and in many animals on subsequent days after irradiation.

Graph 1 shows that the number of leukocytes in the circulating blood decreases in direct proportion to the dose employed. With larger doses the drop in leukocytes is evident one day after irradiation and reaches its maximum approximately six days after exposure with a gradual return to normal or above normal if the animals survive.

Parabiotic Mice

The effect of varying doses of roentgen rays on the number of leukocytes in the circulating blood was studied in 12 sets of parabiotic mice and 24 additional single controls. In each experiment 1 parabiont and 1 single mouse were irradiated with

doses varying between 400 a[redacted]teen days later. Graph III shows

400 or 450 r. Three sets of[redacted]e is a greater decrease in the num-

twins (No. 9, 11, 13) and 6 singl[redacted]eukocytes in the single mice ir-

studied. One parabiont of each[redacted] with 800 r than in the twin ir-

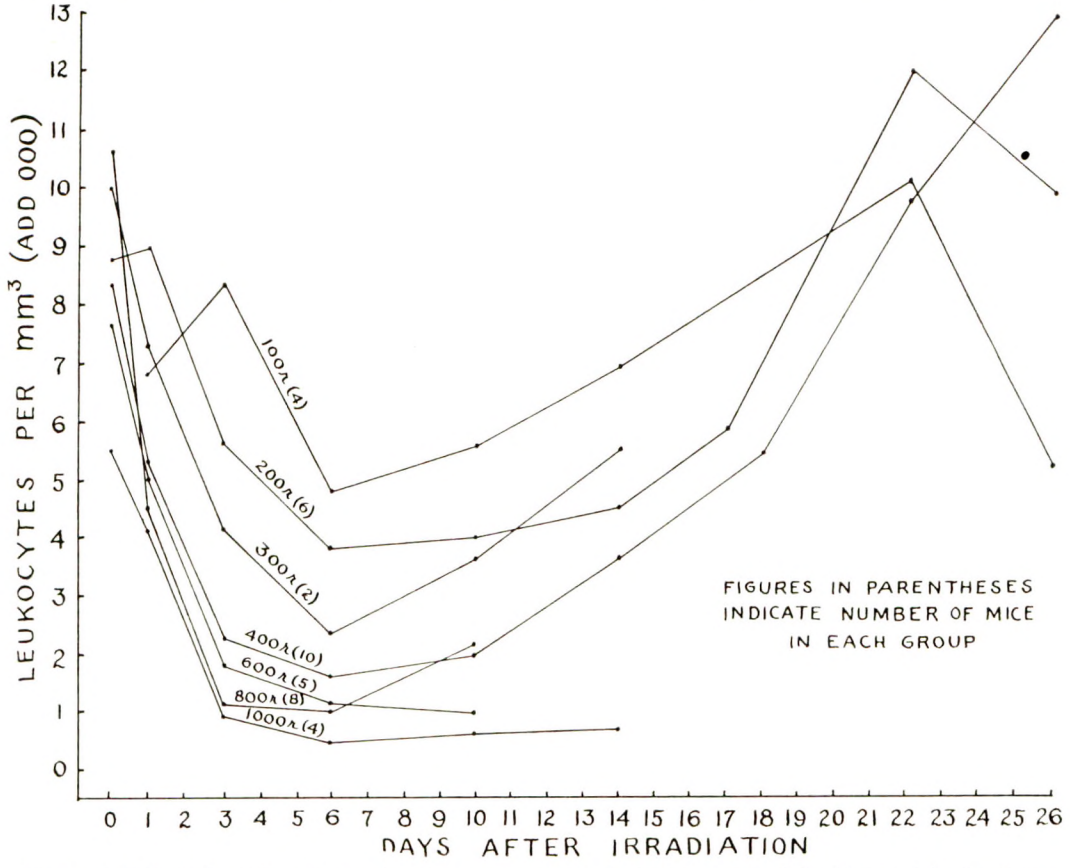
single mice received 450 r. T[redacted]o. 13 radiated with the same dose. Return of the

and 1 single mouse received an additional leukocyte level toward normal is evident

400 r one month after the first irradiation. after ten days in the irradiated parabiont

Graph II shows that the average number but not in the irradiated single mouse. The

of leukocytes after irradiation with 400 or non-irradiated parabiont shows slight leu-



GRAPH I. Effect of varying doses of roentgen rays on the leukocyte level of the blood of single mice.

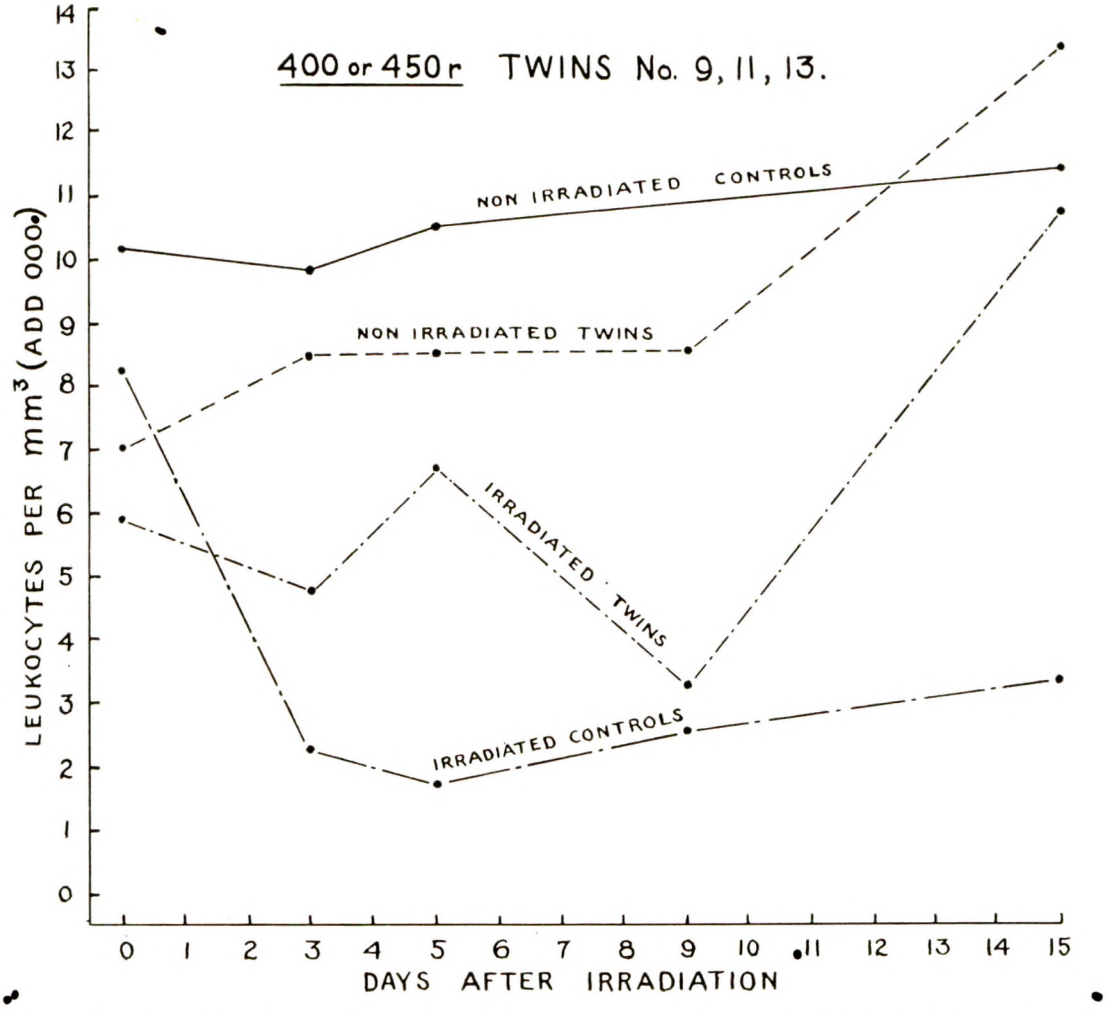
450 r was decreased very markedly in the single irradiated mouse, much less in the irradiated parabiont, and not at all in the non-irradiated parabiont. Parabiotic union with a non-irradiated mouse prevented conspicuous depression of the leukocyte level of the irradiated parabiont.

800 r. In seven experiments 1 parabiotic and 1 single m[redacted]se were exposed to 800 r, while the oth[redacted] parabiont and another single mouse were shielded. One parabiont of Twin No. 149 received an additional kopenia, which was not evident in the parabiont whose twin received only 450 r (Graph II).

1000 r. In this experiment 2 sets of parabiotic twins and 4 single control mice were used. Graph IV shows that irradiation with 1,000 r lowered the number of leukocytes greatly in the irradiated control, slightly less in the irradiated parabiont and considerably less, but definitely, in the non-irradiated parabiont.

Comment. These experiments show that

when one member of a pair of parabiotic mice was irradiated with from 450 to 1,000 r there was leukopenia in the irradiated parabionts, the degree being in direct proportion to the quantity of roentgen rays employed. There was no leukopenia in the non-irradiated parabiont after exposure of its twin to 450 r. When its twin received 800 or 1,000 r there was moderate to marked drop in the leukocyte level of the non-irradiated parabiotic mouse. The reduction of the number of leukocytes in the irradiated parabiont is less marked than in the irradiated single control and the return toward normal occurs sooner.



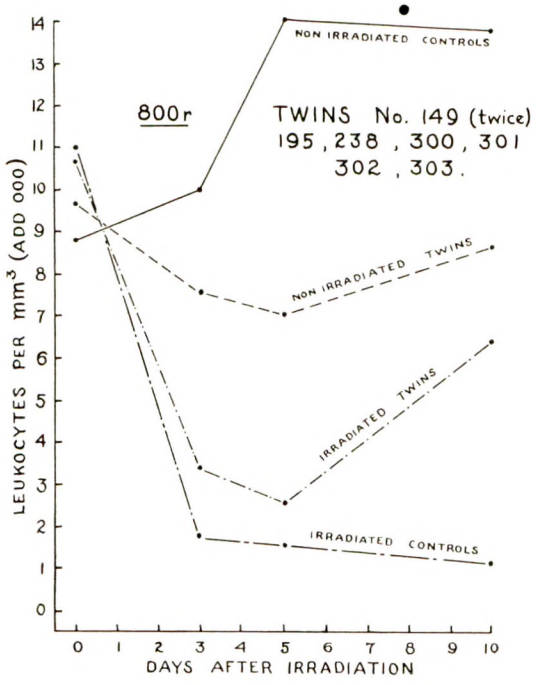
Graph II. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 400 or 450 r.

QUALITATIVE CHANGES IN THE BLOOD PICTURE PRODUCED BY ROENTGEN RAYS IN SINGLE AND PARABIOTIC MICE

It is well known that lymphoid cells are most sensitive to roentgen rays, and that their number in the blood of irradiated animals decreases more rapidly than that of cells of the myeloid series.

Single Mice

In order to compare the qualitative changes in the blood picture of parabiotic mice with those in single mice following irradiation, differential counts of 9 single mice exposed to 400 r were made for



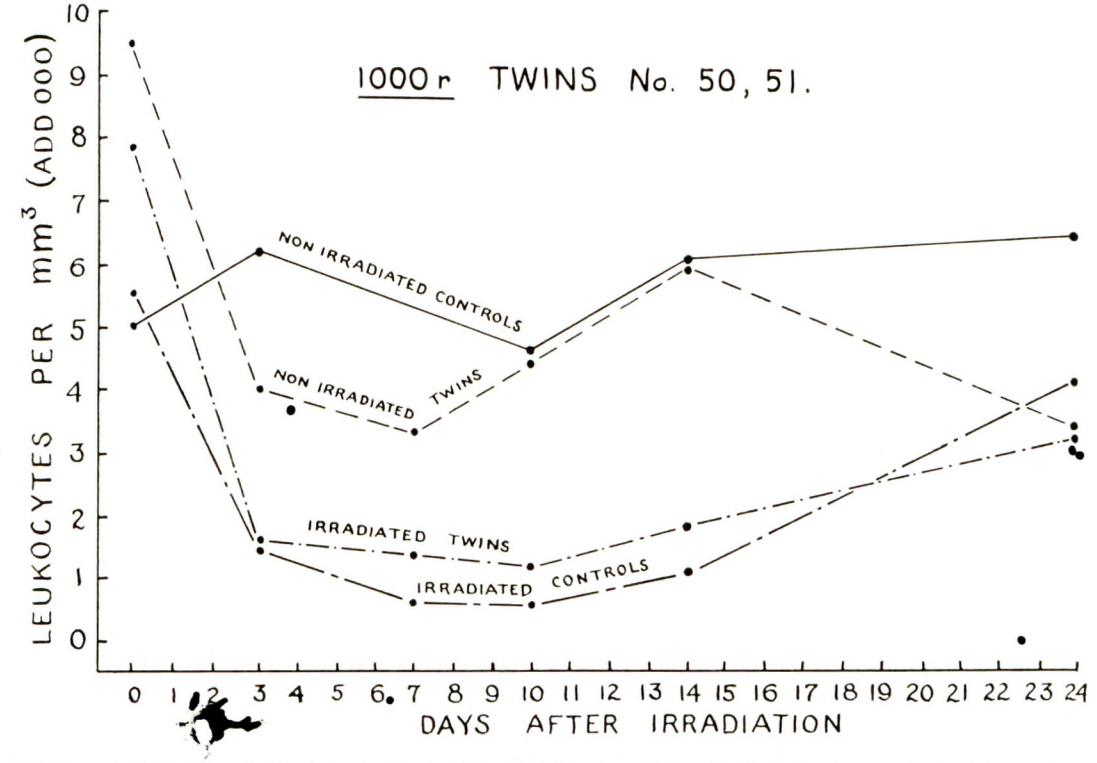
GRAPH III. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 800 r.

period of fifty-four days. In Graph v the average numbers of polymorphonuclear leukocytes and lymphocytes are plotted before and at varying intervals after irradiation together with the total number of leukocytes.

After one day, a conspicuous fall in the number of circulating lymphocytes and a slight rise of polymorphonuclears was noted. Thereafter the polymorphonuclear level fell but returned toward normal more rapidly than that of the lymphocytes. By the twenty-sixth day after irradiation there was a polymorphonuclear leukocytosis which fell to normal by the thirty-second day.

Parabiotic Mice

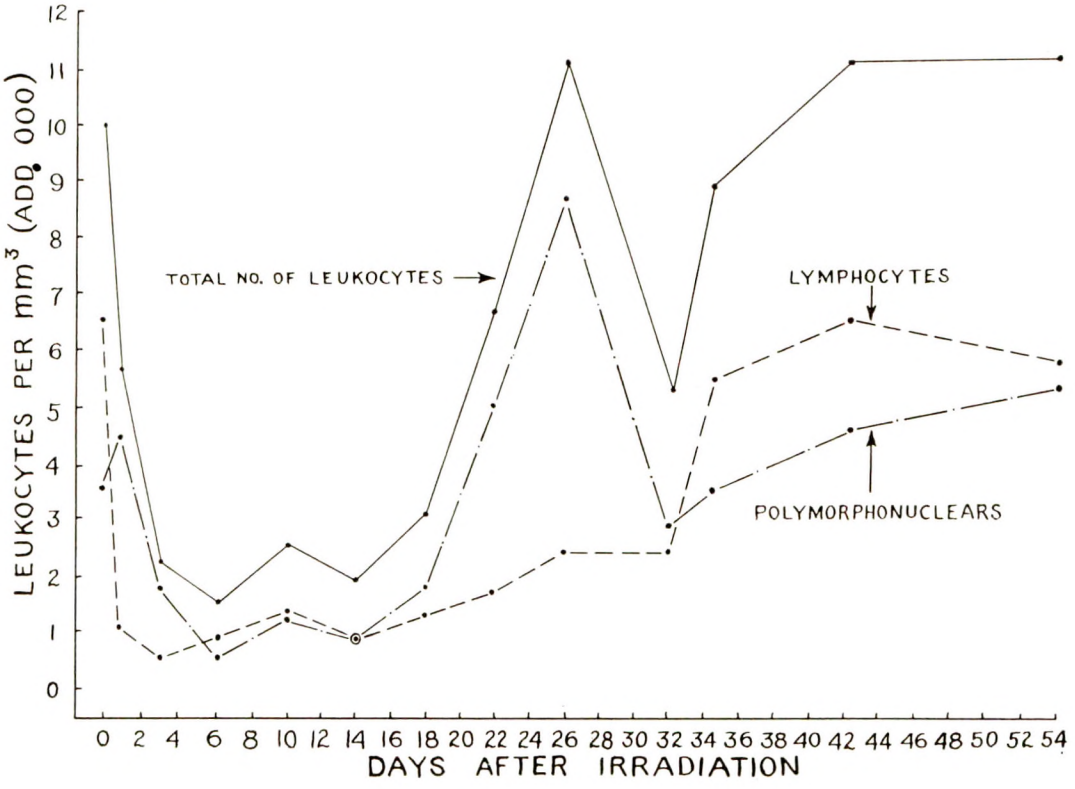
450 r. One member of a parabiotic pair and a single control mouse were irradiated with 450 r. Total and differential leukocyte counts were made of the irradiated mice



GRAPH IV. Effect on the leukocyte level of parabiotic mice of irradiation of one member with 1,000 r.

before and after irradiation as well as of the non-irradiated parabiont and a single non-irradiated control. The results are shown in Graph VI.

Graph VI shows a rapid drop in the number of lymphocytes in the irradiated single control mouse, while the lymphopenia of the irradiated parabiont is less marked. The changes in the differential count are combined and recorded in Graph VII. In the irradiated single mice there was a sudden and profound drop of all leukocytes. In the irradiated parabionts the decrease is similar, but to a lesser degree. The non-irradiated parabionts show a very slight lymphopenia with leukocytosis two weeks

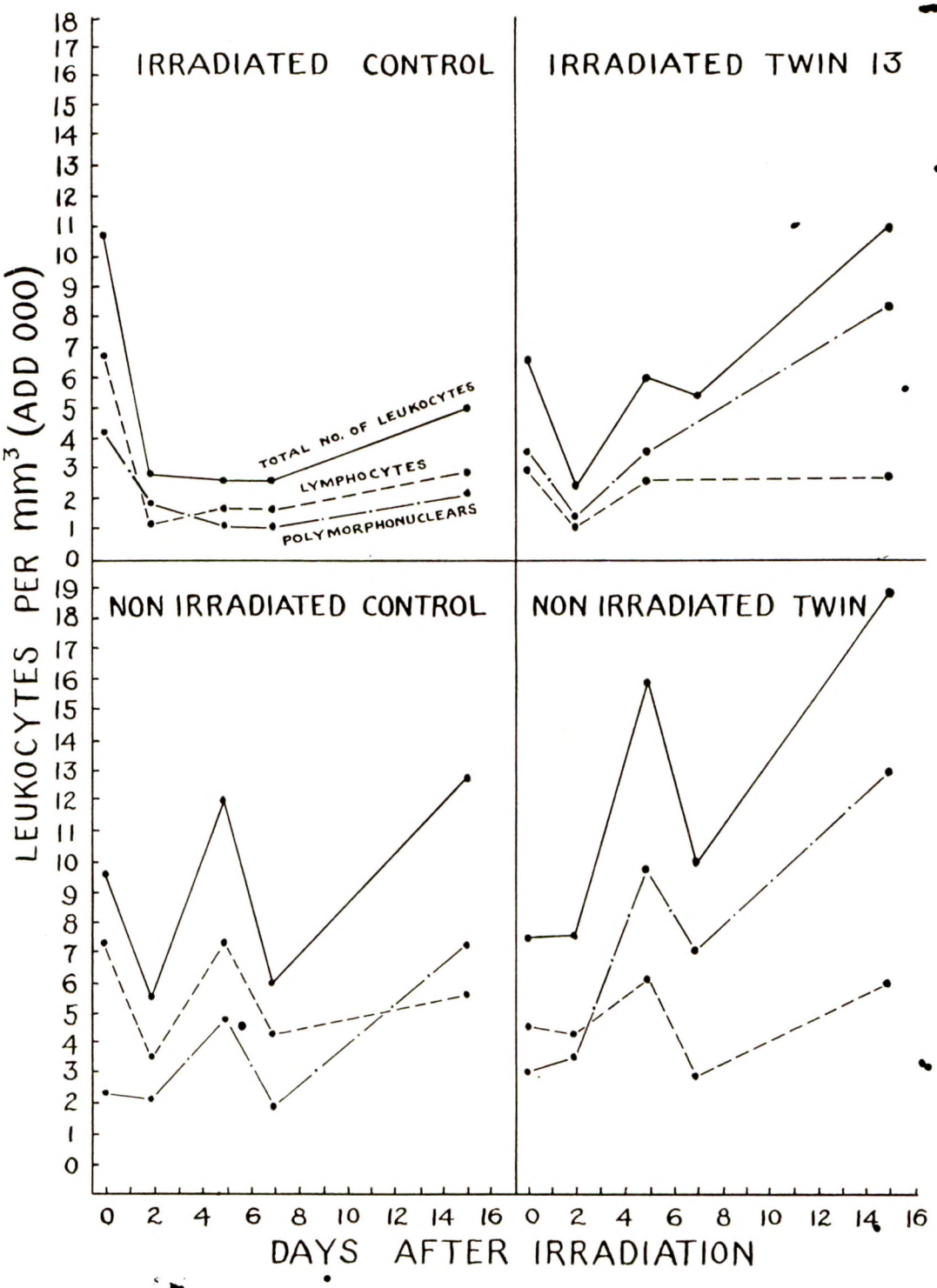


Graph V. Total and differential leukocyte counts on nine single mice irradiated with 400 r.

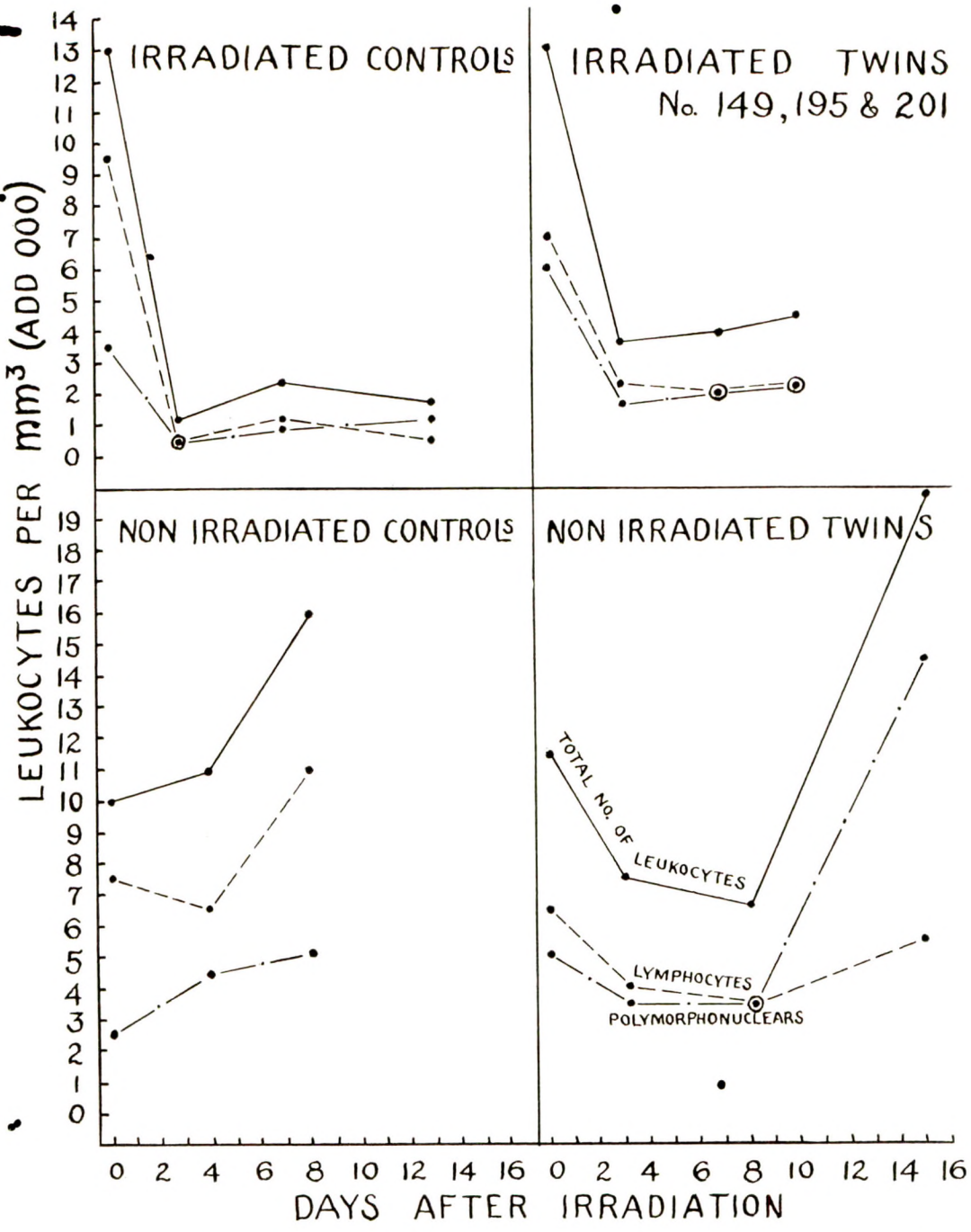
There is a rise of polymorphonuclears and lymphocytes in both the irradiated and non-irradiated parabiont five days after irradiation of the former. The changes in the leukocyte level of the irradiated mouse of this parabiotic pair are obscured because of the preponderance of polymorphonuclear leukocytes before irradiation. However, the effect of irradiation on the lymphocytes in the irradiated twin is less than on those of the irradiated control.

800 r. One member each of 3 parabiotic pairs and 3 control mice were irradiated after irradiation, due to an increase of polymorphonuclear leukocytes.

1,000 r. After irradiation of 1 member of each of 2 parabiotic pairs with 1,000 r the lymphocytes drop very rapidly in the irradiated mouse; similarly, but to a lesser degree, in the non-irradiated parabiont. In the non-irradiated twins there is a more rapid recovery of the lymphocytes than in the irradiated single mice which show profound depression of lymphocytes with no significant recovery after two weeks (Graph VIII).



GRAPH VI. Quantitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 450 r.



GRAPH VII. Qualitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 800 r.

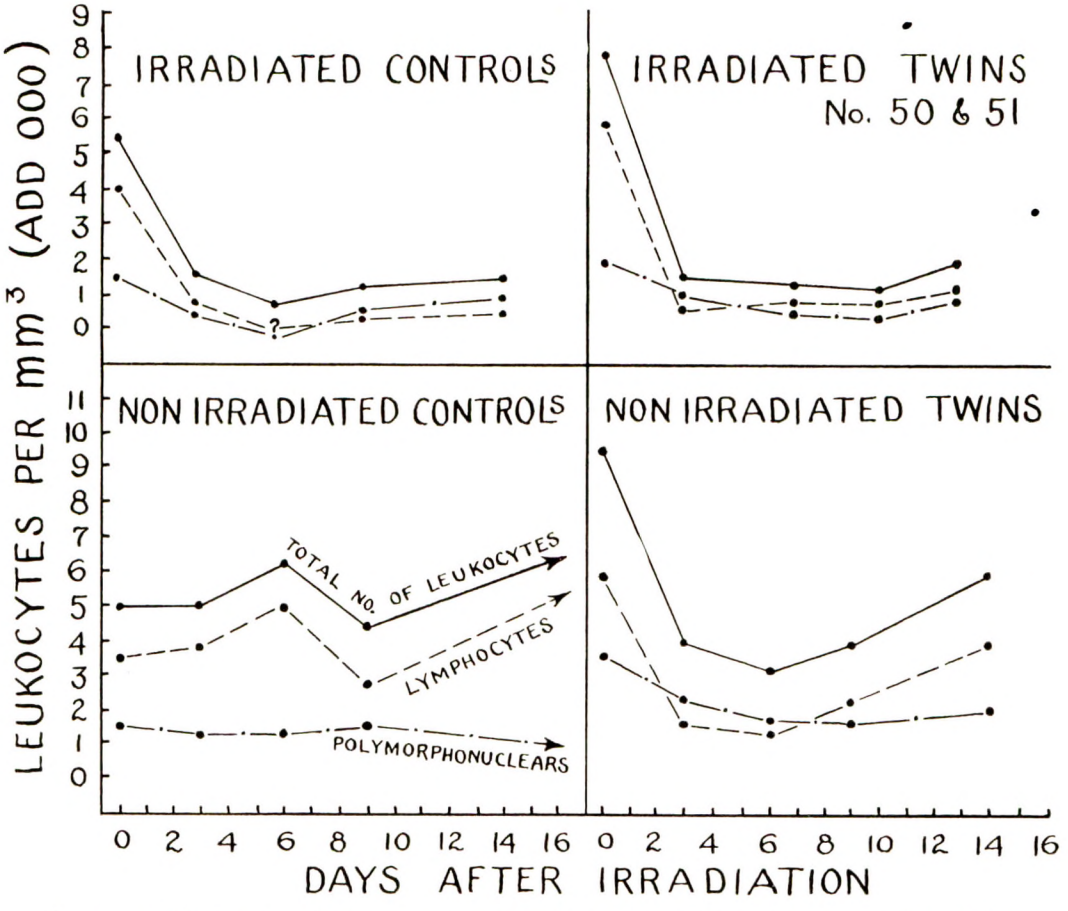
DISCUSSION

Changes similar to those described by others in bone marrow and lymphoid tissues of animals following exposure to roentgen rays have been observed by us. In our experiments, while a large single dose (1,500 r) of roentgen rays produced, after several hours, pyknosis in non-exposed marrow of rabbits, tremendous single doses (6,000 r) directed to a large part of the bodies of mice

failed to produce significant destructive changes in non-exposed marrow from one to several days after irradiation. However, hyperemia, increased numbers of polymorphonuclear leukocytes and later hyperplasia were found. The lymphoid tissues are more susceptible to indirect irradiation.

number in the lymph follicles, while Hsü and Ma[15] irradiated their rats daily during at least eight days and remark "the changes in the lymph node, spleen and unirradiated bone marrow point to hyperactivity of the hematopoietic tissue."

In our experiments with mice, rats and



GRAPH VIII. Qualitative changes in the leukocyte level of parabiotic mice following irradiation of one member with 1,000 r.

Exposure of the abdomen of rats to 3,000 r is followed in several hours by pyknosis of lymphoid cells in the thymus,[cf. 24] and similar changes have been described in non-exposed lymph nodes of irradiated rats and rabbits.[1,15]

In studying the indirect effects of irradiation, Akaiwa and Takeshima[1] exposed their rats to a single dose of roentgen rays and found disintegration of lymphocytes with consequent decrease in their

rabbits, there was conspicuous fragmentation and pyknosis in lymph nodes shielded from the direct action of roentgen rays as early as two hours following exposure to large doses. The following observations suggest that the magnitude of the indirect effect of irradiation is dependent, at least in part, on the volume of tissue exposed, and not alone on the dose of roentgen rays. When 7,280 r was applied to the ear of a rabbit there were no significant changes in

distant non-irradiated lymph nodes. When a smaller dose (2,560 or 3,000 r) was directed to one leg, however, fragmentation and pyknosis of non-irradiated nodes were noted, which were more conspicuous when the entire lower half of the body was irradiated. When the tails only of 6 mice were exposed to 6,400 r there were no significant changes in the lymphoid tissue several hours after irradiation, although smaller doses applied to one-half the body produced conspicuous changes in unexposed lymph nodes.

These observations lend support to the opinion that there is a "factor" produced in an irradiated animal which exerts deleterious effects in parts of the body not directly exposed to the roentgen rays.

In regard to the specificity of changes produced by irradiation, Packard[31] pointed out that cells that are susceptible to roentgen rays are also susceptible to many other agents. In our experiments changes in lymph nodes and bone marrow following actual cautery applied to the skin and following iodoacetic acid poisoning were similar to those observed in unexposed organs of irradiated animals. Such experiments suggest that the changes produced in non-irradiated tissues are due to non-specific factors arising in the irradiated tissues and transported via the blood stream.

The existence of a "toxic" factor in the blood has been described by Macht,[27] who examined by phytopharmacological methods blood from animals and humans before and after irradiation. Blood withdrawn twenty-four hours after irradiation inhibited the growth of seedlings. The "toxic" factor responsible for these phytopharmacological changes, however, has not been demonstrated in the blood within a few hours after irradiation when the changes in non-irradiated tissues are first observed.

The method of parabiosis offers a means to study further the character of the indirect effect of irradiation. If a mouse is joined in parabiosis and irradiated, while its parabiont is completely shielded, alterations in the blood forming organs are similar to those occurring in a single irradiated mouse, but quantitatively there is slightly less damage in the irradiated parabiotic animal. The changes in the non-irradiated parabiont following 800 r to its twin are slight. After a very large dose (6,000 r) to one parabiont, there was hyperemia of spleen and bone marrow, fragmentation of nuclei of lymphoid cells in thymus, lymph node and spleen of its non-irradiated twin seven hours after irradiation. These changes were not present in the non-irradiated parabiont seventy-two hours after irradiation, and were not found four to six days after irradiation with 3,200 r.

Leukopenia occurs in a shielded parabiotic mouse after exposure of its twin to 800 to 1,000 r but the mechanism is not understood. There are at least two possible explanations. Erythrocytes injected into one parabiotic mouse are present in large numbers in the uninjected parabiont after several minutes.[12] Therefore the altered blood of the irradiated parabiont presumably circulates in the vessels of the non-irradiated animal. It may be that following the fall in the number of leukocytes in the irradiated twin, leukocytes migrate from the non-irradiated to the irradiated parabiont. This would result in slight leukopenia in the non-irradiated mouse and would prevent the leukopenia in the irradiated twin from reaching the same low level observed in a single mouse similarly irradiated. Or it is possible that the blood of the irradiated animal is so altered that when it passes to the non-irradiated parabiont it depresses the leukocyte level of the latter, but being diluted in the blood of the non-irradiated parabiont leukopenia is less in the irradiated twin than in a single mouse similarly irradiated. Both mechanisms may operate.

Leukopenia in an irradiated parabiont is less severe than that in an irradiated single animal. With moderate doses of roentgen rays, changes in the blood forming tissues of the non-irradiated parabiont are slight and the leukopenia is transient.

Differential counts show that the decreased leukocyte level in the irradiated twin is due to a fall in both myeloid and lymphoid cells, more especially the latter. The leukopenia in the non-irradiated twin similarly is due largely to a lymphopenia.

This can be explained either by passage of lymphocytes from shielded to irradiated animal or by the transfer of a noxious agent from the irradiated to shielded twin. Evidence for the former has been presented; the degenerative changes in the lymphoid tissues of shielded twins whose twin had received large doses of roentgen rays indicate passage of this toxic agent.

These experiments suggest the possibility that an animal united to another by parabiosis might survive larger doses of roentgen rays. A few experiments have supported this assumption. Single mice almost invariably die following exposure to 1,000 r, but if joined to another mouse by parabiosis they may survive.

SUMMARY AND CONCLUSIONS

Roentgen irradiation produces pathological changes in unexposed lymphoid tissue and bone marrow of rodents. This injury is due to nonspecific factors carried from damaged tissue by way of the circulatory system, and its degree depends, among other factors, on the dose of roentgen rays and probably on the volume of tissue irradiated. The indirect damage is slight as compared to the direct effect.

Parabiosis diminishes the deleterious effects of irradiation. When one member of a parabiotic pair is irradiated, the pathological changes in the blood and blood forming tissues of the irradiated mouse are less conspicuous than those in a single mouse similarly irradiated, while in the non-irradiated parabiont the changes are only slight. These observations indicate that the indirect effect of roentgen rays on lymphoid tissue and bone marrow are due to humoral factors.

REFERENCES

1. AKAIWA, H., and TAKESHIMA, M. Reaction of lymphoid tissue to roentgen radiation. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 42–46.
2. VON ALBERTINI, A. Die "Flemming'schen Keimzentren." *Beitr. z. path. Anat. u. z. allg. Path.*, 1932, *89*, 183–228.
3. AUBERTIN, C., and BEAUJARD, E. Action des rayons X sur le sang et les organs hematopoietiques. *Compt. rend. Soc. de biol.*, 1905, *58*, 217–219.
4. BEHNE. Versuch einer Analyse der biologischen Strahlenwirkung. *Deutsche med. Wchnschr.*, 1920, *46*, 223–224.
5. BRINNITZER, H. N. Blutkrankheiten als Strahlenfolge. *Strahlentherapie*, 1935, *52*, 699–716.
6. BUNSTER, E., and MEYER, R. K. An improved method of parabiosis. *Anat. Rec.*, 1933, *57*, 339–343.
7. CASPARI, W. Biologische Grundlagen der Strahlenbehandlung bösartiger Geschwülste. In: Handbuch d. ges. Strahlenheilkunde. P. Lazarus, Editor. Vol. 1. J. F. Bergmann, München, 1928.
8. COLWELL, H. A. The Method of Action of Radium and X-Rays on Living Tissues. Oxford University Press, London, 1935.
9. COLWELL, H. A., and RUSS, S. Radium, X Rays and the Living Cell. Second edition. G. Bell & Sons, London, 1924.
10. DESJARDINS, A. U. Radiotherapy for inflammatory conditions. *J. Am. M. Ass.*, 1931, *96*, 401–408.
11. FAILLA, G. A theory of the biological action of ionizing radiations. *Cancer Probl., Symposium*, 1937, pp. 202–214.
12. FURTH, O. B., BARNES, W. A., and BROWER, A. B. Studies on resistance to transmissible leukemia in mice by means of parabiosis. *Arch. Path.*, 1940, *29*, 163–174.
13. HEINEKE, H. Ueber die Einwirkung der Röntgenstrahlen auf die Tiere. *München. med. Wchnschr.*, 1903, *2*, 2090–2092. Zur Kenntnis der Wirkung der Radiumstrahlen auf tierische Gewebe. *München. med. Wchnschr.*, 1904, *2*, 1382–1384. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf innere Organe. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1905, *14*, 21–94.
14. HELBER, E., and LINSER, P. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf das Blut. *München. med. Wchnschr.*, 1905, *1*, 689–691.
15. HSÜ, C. L., and MA, W. C. Direct and indirect effects of roentgen radiation on the blood-forming organs of rats. *Am. J. Cancer*, 1940, *39*, 319–333.

16. HUSSEY, R. G. Influence of x-rays on properties of blood. *J. Gen. Physiol.*, 1922, *4*, 511–516.
17. JOLLY, J., and LACASSAGNE, A. De la résistance de leucocytes du sang vis-à-vis de rayons X. *Compt. rend. Soc. de biol.*, 1923, *89*, 379–382.
18. JOLLY, J. Mode d'action des rayons X sur les cellules. *Compt. rend. Soc. de biol.*, 1924, *91*, 79–80. Action de rayons X sur les cellules. *Compt. rend. Soc. de biol.*, 1924, *91*, 532–534.
19. KLUGE, L., and ZWERG, H. G. Ueber die Wirkung der Röntgenbestrahlung auf den Mineralstoffwechsel von multiplen Impfsarkomen der weissen Ratte. *Strahlentherapie*, 1933, *46*, 293–310.
20. KNOTT, F. A., and WATT, W. L. Some effects of deep x-rays upon the cells of the blood. *Brit. M. J.*, 1929, *1*, 542–543.
21. KRAUSE, P., and ZIEGLER, K. Experimentelle Untersuchungen über die Einwirkung der Röntgenstrahlen auf tierisches Gewebe. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1906–1907, *10*, 126–182.
22. KRÖMEKE, F. Ueber die Einwirkung der Röntgenstrahlen auf die roten Blutkörperchen. *Strahlentherapie*, 1926, *22*, 608–652.
23. LANGER, H. Roentgen rays and the autonomic nervous system. AM. J. ROENTGENOL. & RAD. THERAPY, 1927, *18*, 137–145.
24. LEBLOND, C. P., and SEGAL, G. Action des toxiques sur le thymus de l'animal sans surrénale. *Compt. rend. Soc. de biol.*, 1938, *129*, 838–840.
25. LEWIS, W. H., and LEWIS, M. R. General Cytology. University of Chicago Press, Chicago, 1924.
26. LIECHTI, A. Ueber Reaktionsänderungen im Röntgenbestrahlten Gewebe. *Klin. Wchnschr.*, 1926, *5*, 1911–1913.
27. MACHT, D. I. Pharmacology of human blood after its exposure to roentgen rays. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *45*, 446–449.
28. MINOT, G. R., and SPURLING, R. G. Effect on the blood of irradiation, especially short wave length roentgen-ray therapy. *Am. J. M. Sc.*, 1924, *168*, 215–241.
29. MOTTRAM, J. C. Action of radium on blood supply: white reaction. *Brit. J. Radiol.*, 1932, *5*, 643–645.
30. PACK, G. T. Pathology of burns. *Arch. Path. & Lab. Med.*, 1926, *1*, 767–805.
31. PACKARD, C. Biological effects of short radiations. *Quart. Rev. Biol.*, 1931, *6*, 253–280.
32. v. PANNEWITZ, G. Beeinflussung des Säure-Basenhaushaltes durch Röntgenstrahlen. *Strahlentherapie*, 1926, *24*, 327–330.
33. RASPE, R. Biologische Wirkung der Strahlen mit besonderer Berücksichtigung der Tuberkuloseforschung. *Zentralbl. f. d. ges. Tuberk.-Forsch.*, 1939, *49*, 513–531.
34. REGAUD, C. L., and LACASSAGNE, A. Die Histophysiologische und pathologisch-anatomischen Grundlagen der Strahlenbiologie und -Therapie. In. Handbuch d. ges. Strahlenheilkunde. P. Lazarus, Editor. Vol. 1. J. F. Bergmann, München, 1928, pp. 258–304.
35. ROTHER, J. Ueber den Angriffspunkt der Röntgenstrahlenwirkung am biologischen Objekt. *Strahlentherapie*, 1928, *27*, 197–256.
36. SCOTT, C. M. Some Quantitative Aspects of Biological Action of X and γ Rays. Med. Research Council, Special Report Series, No. 223. His Majesty's Stat. Off., London, 1937.
37. SHOUSE, S. S., WARREN, S. L., and WHIPPLE, G. H. Aplasia of marrow and fatal intoxication in dogs produced by roentgen radiation of all bones. *J. Exper. Med.*, 1931, *53*, 421–435.
38. SICILIANO, L., and BUONAMICI, C. B. Studi sul midollo osseo sotto l'azione dei raggi X. *Arch. di radiol.*, 1930, *6*, 1108–1136.
39. SIPOWSKY, P. W. Directe und "reflektorische" Wirkung auf das Knockenmark. *Vestn. rentgenol.*, 1934, *13*, 263–269. Quoted from *Zentralbl. f. d. ges. Radiol.*, 1935, *19*, 551–552.
40. STEDMAN, D. F., and LAURENCE, G. C. A poison theory of the effects of irradiation. Third International Cancer Congress, 1939.
41. TAYLOR, H. D., WITHERBEE, W. D., and MURPHY, J. B. Studies on x-ray effects. *J. Exper. Med.*, 1919, *29*, 53–73.
42. TSUZUKI, M. Experimental studies on biological action of hard roentgen rays. AM. J. ROENTGENOL. & RAD. THERAPY, 1926, *16*, 134–150.
43. WEISKOTTEN, H. G. Histopathology of superficial burns. *J. Am. M. Ass.*, 1919, *72*, 259–261.
44. WOENCKHAUS, E. Beitrag zur Allgemeinwirkung der Röntgenstrahlen. *Arch. f. exper. Path. u. Pharmakol.*, 1930, *150*, 182–197.
45. WÜNSCHE, H. W. Fortlaufende Untersuchungen über den Einfluss der Röntgenstrahlen auf das Knochenmark. *Arch. f. exper. Path. u. Pharmakol.*, 1938, *189*, 581–599.
46. ZACHERL, H. Beitrag zur Allgemeinwirkung der Röntgenstrahlen. *Strahlentherapie*, 1926, *23*, 272–287.
47. ZWERG, H. G. Ueber die Allgemeinwirkung der Röntgenstrahlen mit besonderer Berücksichtigung ihres zeitlichen Auftretens. *Strahlentherapie*, 1932, *45*, 297–306.

AN INVESTIGATION INTO SOME PRACTICAL ASPECTS OF ROENTGEN-RAY STEREOPTICS*

PART I. A FALLACY IN THE CURRENT PRACTICE OF STEREOROENTGENOGRAPHY

PART II. SINGLE-FILM STEREOROENTGENOGRAMS—A NEW AND SIMPLE METHOD OF STEREOROENTGENOGRAPHY

PART III. A DEVICE FOR MEASURING DEPTH IN SINGLE-FILM STEREOROENTGENOGRAMS

By EDWARD KLEIN, D.D.S., MILTON KLEIN, D.D.S., HAROLD KLEIN, D.D.S.,† *and* ALLEN T. NEWMAN, M.D.‡

NEW YORK, NEW YORK

PART I

A FALLACY IN THE CURRENT PRACTICE OF STEREOROENTGENOGRAPHY

THE principle of stereoptics is well known. Objects viewed with a normal pair of eyes appear to have depth and distance because of man's natural stereoscopic vision. Each eye receives a slightly different view and the two images are fused by the brain to give the stereoscopic impression. Similarly if two photographs of the same object are made from slightly different positions and then viewed in some type of stereoscope so that each eye sees only one image, the brain can fuse the two images into one so that a true perspective in the correct spatial relation will be seen and an impression of depth received.

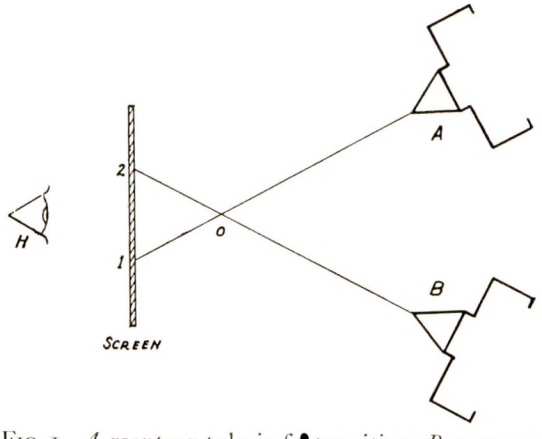


FIG. 1. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *O*, object; *1*, shadow of object (*O*) on screen from roentgen tube (*A*); *2*, shadow of object (*O*) on screen from roentgen tube (*B*); *H*, eye.

Following the discovery of the roentgen rays, Sir J. MacKenzie Davidson applied this photographic stereoptical principle to roentgenography. Davidson's application is still used and has not been essentially changed up to the present time. The following quotation from the "Manual" by Sante[1] presents the modern concept:

> Stereoscopic roentgenography is based on the same principle as stereoscopic vision. The two eyes see an object from two different viewpoints, approximately 2.5 inches apart—the average distance between the pupils of the two eyes. The two images thus secured are correlated in the brain giving the sense of depth.
>
> In stereoscopic roentgenography, the same principle is carried out; two separate exposures are made, with different positions of the focal point of the tube 2.5 inches apart, without disturbing the position of the patient. If the eyes are placed in the two positions of the focal spot they would obtain similar impressions to those recorded by the two X-ray exposures on the X-ray films. If by means of a stereoscope, these two roentgenograms are viewed simultaneously, the right eye viewing the roentgenogram taken by the right shift of the target, the

[1] Sante, L. R. Manual of Roentgenological Technique. Edwards Brothers, Inc., Ann Arbor, Mich., 1940.

* Presented at New York University College of Dentistry, August 7, 1942, and at Walter Reed Hospital, Washington, D. C., October 20, 1942.

† Research Associates in Radiology— New York University.

‡ Dean, New York University College of Dentistry; Director of Research Clinics.

left eye viewing the roentgenogram taken by the left shift of the target, then the two images will be correlated in the brain giving a sense of depth to the subject.

The results obtained by this technique have not been satisfactory because it has not been recognized that, while the basic principle of stereoptics remains unchanged and unchangeable, its application in roentgenography is different from that in photography. A photograph is the image of an object; a roentgenogram is the image of the *shadow* of an object cast upon a screen at some distance from the object. A roentgenogram is, therefore, the picture of a shadow.

The New Concept. The new concept depends upon recognition of this fact that what the eye sees in a roentgenogram is not the object itself but the *shadow* of the object. Figure 1 makes this clear. The first position of the roentgen tube (*A*) casts a shadow of the object (*O*) at (*1*). The second position of the roentgen tube (*B*) casts a shadow of the object (*O*) at (*2*). Because the eye (*H*) views the *shadow* of the object and not the object itself, it is the amount of *displacement of the shadows*, that is to say, the distance between (*1*) and (*2*) which is the controlling factor and not the distance which the roentgen tube moves.

Since the eyes do not view the object from the same position as does the roentgen tube, the tube should not be moved as if it were a camera. We have established by trial and error that if the shadow displacement is greater than $\frac{3}{8}$ inch the average individual viewing these two roentgenograms through a stereoscope at reading distance will not be able to fuse the two images to obtain a sense of depth. Only young individuals or persons of considerable experience with stereoptical pictures can fuse displacements of greater degree. Recognition of this fact is what has made successful stereoroentgenograms possible.

How to Calculate the Correct Displacement of the Tube. The shadow of the part of the object nearest the roentgen tube and farthest away from the film is displaced the greatest distance when the roentgen tube is moved. Thus in Figure 2 the shadow of (*C*) has a greater displacement than the shadow of (*D*). Moreover, the farther the object is away from the film, the greater will be its displacement. But as explained, the shadows thrown by (*C*) must not be greater than $\frac{3}{8}$ inch apart. If, then, it is arranged that no matter what distance (*C*) is away from the film, the displacement shall be *not more* than $\frac{3}{8}$ inch, then the shadows of all other points will have less

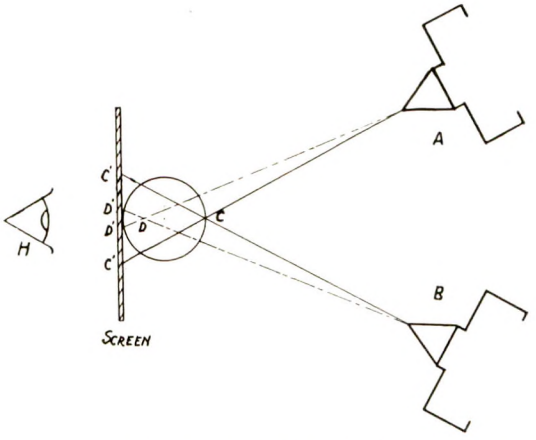


FIG. 2. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *C*, point of object farthest away from screen; *C'*, shadow of object (*C*) from roentgen tubes (*A*) and (*B*); *D*, point of object nearer than (*C*) to the screen; *D'*, shadow of object (*D*) from roentgen tubes (*A*) and (*B*); *H*, eye.

displacement than $\frac{3}{8}$ inch and thus be readily fusible. In other words, the maximum amount of displacement being fixed, the amount of movement of the tube has to vary for each object to be roentgenographed. This distance can be calculated very simply.

Example 1

In Figure 3, $\frac{3}{8}$ inch displacement of the shadow of (*C*) is required.

Most distant point of object from film..10 in.
Anode to point of object.....20 in.
Film-anode distance.....30 in.

Then $\frac{3}{8}:10::X:20$. Therefore $X=\frac{3}{4}$ in.

Example 2

Take another instance in which the distance of the object (*C*) from the film is 6 inches and from the anode 30 inches. Then $\frac{3}{8}:6::X:30$. Therefore $X=1\frac{7}{8}$ in.

Thus in Example 1, $\frac{3}{8}$ inch displacement will be obtained if the roentgen tube is moved between each exposure a distance of $\frac{3}{4}$ inch in a horizontal straight line. In Example 2, however, the tube will need to be moved $1\frac{7}{8}$ inch to obtain the same displacement.

When this formula is strictly adhered to, the two resultant roentgenograms are fusible for the average individual and can justly be called true stereoroentgenograms.

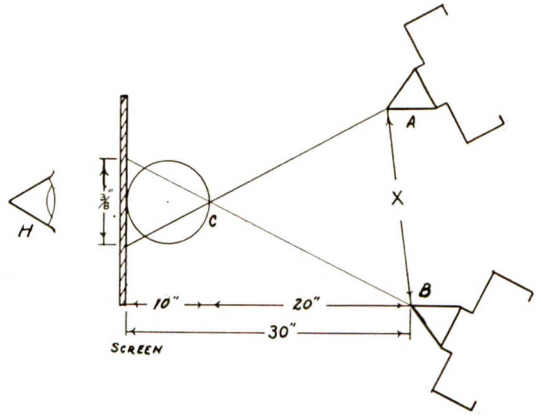


FIG. 3. *A*, roentgen tube in first position; *B*, roentgen tube in second position; *C*, point of object farthest away from screen; *H*, eye; *X*, distance of roentgen tube shift from (*A*) to (*B*).

The procedure for taking these stereoroentgenograms is the usual one. When taking the first roentgenogram the operator directs the tube at the object in the usual way. He then moves the tube to his left the calculated distance. In order to facilitate this, the rod carrying the tube should be calibrated in eighths of an inch. Since at present this is not done, the calculated distance must for the time being be measured with a ruler. The second exposure is then made.

The films so obtained may be viewed by any method such as the converging lens stereoscope or the reflecting mirror (Wheatstone) stereoscope at reading distance.

Summary. It has been shown that the current practice of producing stereoroentgenograms based on the photographic principle of the interpupillary distance is incorrect.

Because the roentgenogram is not an image of the object but a *shadow* of that object, allowance has to be made for the distance of the object from the film.

It has been found that the maximum deviation between the shadows on the two roentgenograms which can be readily fusible by the average individual is $\frac{3}{8}$ inch.

For this reason, the displacement of the tube must be varied in each case to insure that no more than this maximum deviation be produced.

The formula for calculating the displacement of the tube is given.

PART II

SINGLE-FILM STEREOROENTGENOGRAMS— A NEW AND SIMPLE METHOD OF STEREOROENTGENOGRAPHY

In Part I we have demonstrated a fallacy in the current practice of making stereoroentgenograms, and a new technique of taking stereoroentgenograms which makes them readily readable by even the inexperienced eye. In this part we are concerned with a method of using this technique to produce on a single film a roentgenogram which, when viewed through polarizing spectacles, gives the same effect of depth as when two roentgenograms taken from different angles are viewed in a stereoscope. Cumbersome and costly stereoscopic apparatus thus becomes unnecessary.

The Single-Film Stereoroentgenogram. A single tri-dimensional film has been adopted for this purpose. The principle of this special film is that each side of it polarizes the light at right angles to the other. The image on each side corresponds respectively to the images of the two stereoscopic roentgenograms. These are viewed through special spectacles, each lens of which is polarized at right angles to the other. The degree of angulation of one side of the print corresponds to the degree of angulation of one lens and that of the other side of the print to the degree of angulation of the other lens. Thus each eye picks up the image of only one side of the negative. These two separate images are fused in the

process the second developed roentgenogram, using the same times for exposures, developing and wash-off bath.

Note: If both films are exposed and processed in the same operation the resulting Wash-Off Relief Films will be of exactly the same quality and there will be a saving of time.

6. Register both Wash-Off Relief Films by putting their gelatin sides face to face so that their edges agree and clip them securely together. The images then overlap each other to the maximum of $\frac{3}{8}$ inch.

7. Now attach a strip of adhesive along the length of the top border of the upper film, with half of its breadth free. Turn the films over and apply another piece of tape similarly so that the free edges of the tape stick to each other. To reinforce this hinge, place an additional strip of adhesive on top of the other two strips on each side, slightly overlapping and sticking to each other. Punch two or three holes, depending on the size of the film, through the hinge where the film ends, so that half the hole is through the films. These are used for drainage of the printing solution which occurs in a later step.

8. Immerse the resulting registered films for one minute in a bleaching solution which takes out the silver stain and hardens the gelatin. Rinse in running water until all the color of the film is washed out. Immerse the films for two minutes in the printing solution, keeping the surfaces of the films apart by a metal rod. The gelatin of the film absorbs the printing solution in proportion to the thickness of the gelatin relief.

9. Remove the films from the solution and spread them apart without detaching them at the hinge. The excess ink drains out through the holes in the hinge.

10. Insert a commercially prepared sheet of special polarizable material between them and pass the three, hinge-first, through a wringer with rubber rollers which apply a moderate pressure. This transfers to each side of the polarizable sheet the respective relief images contained on each Wash-Off Relief Film. The amount of ink transferred determines the degree of polarization, and so produces a roentgenogram of varying densities.

11. Leave the polarizable sheet between the two Wash-Off Relief Films for one minute, then peel them off. At once mark the part of the sheet which was nearest the hinge, "Top." (If the top of the sheet is held at the bottom, the shadows on the roentgenogram will appear to recede instead of advance; and if the right hand picture, instead of the left, is turned, to make the mirror image, the shadows will also recede.)

12. The print is now ready, and appears as two blurred images, as in Figure 4. It may be viewed immediately, through the special spectacles, and will appear in stereoptic relief.

For a permanent record, allow the print to dry for five minutes and lacquer both sides of the polarized sheets to avoid scratching.

This process, though it takes time in the describing, is in fact simple and quick. It does not require more skill than can be reasonably expected from a roentgen-ray technician, and the whole process, from the completed roentgenograms to the wet stereoroentgenogram ready for examination can be completed in seven minutes.

Summary. A method has been described whereby a stereoroentgenogram can be produced on a single film. This single-film stereoroentgenogram, when viewed through polarized spectacles, gives a tri-dimensional view. Moreover, it can be viewed by more than one person at a time, or be projected on a screen and demonstrated to an audience. Reflection type and transparent prints can be studied through a magnifying glass.

It will be apparent, therefore, that the single-film stereoroentgenogram represents a great advance over the two-film stereoroentgenogram which can be viewed only in a special apparatus and by one person at a time. Production of the single-film stereoroentgenogram does not require

brain, producing the stereoptic picture.

The single-film stereoroentgenogram has several advantages over the usual double-film type. It can, for instance, be projected on a screen and thus a stereoscopic view be obtained by a whole audience instead of by one person only at a time.

To do this, the stereoroentgenogram is placed in an ordinary lantern slide projector and projected on a metallic screen, made by painting a glossy surface with aluminum paint. The function of the aluminum screen is to maintain the polarization of light. Alternatively the film may be aluminum-painted on one side and viewed as a reflection type print. Finally, both film and reflection type print can be viewed through a magnifying glass without depolarizing the light and therefore a stereoptic view is still obtained.

How to Produce the Single-Film Stereoroentgenogram. The usual two roentgenograms are taken. When the first has been taken, the tube is moved to the *left* over the distance calculated, as described in Part 1, and the second roentgenogram is taken. This second roentgenogram is known as the *left hand* roentgenogram, and it is important so to mark it for use in the process of developing.

The process described below is now followed.

1. Develop the two exposed films in the normal manner. Lay them down in ordinary viewing position, and turn the second, or *left hand* roentgenogram over. This gives a mirror image to the first roentgenogram. Turn off the light and illuminate the darkroom with a Wratten Safelight, series "O" or "OA." Place a Wash-Off Relief Film (as used in color photography), shiny side up on a flat surface. Place one of the developed roentgenograms over the Wash-Off Relief Film, and then expose it to a light source from above. When using a 10 watt bulb, 3 ft. distance, the exposure time varies from four to twelve seconds. If the film is very thin and the light source too great, the bulb may be obscured to diminish the candle power.

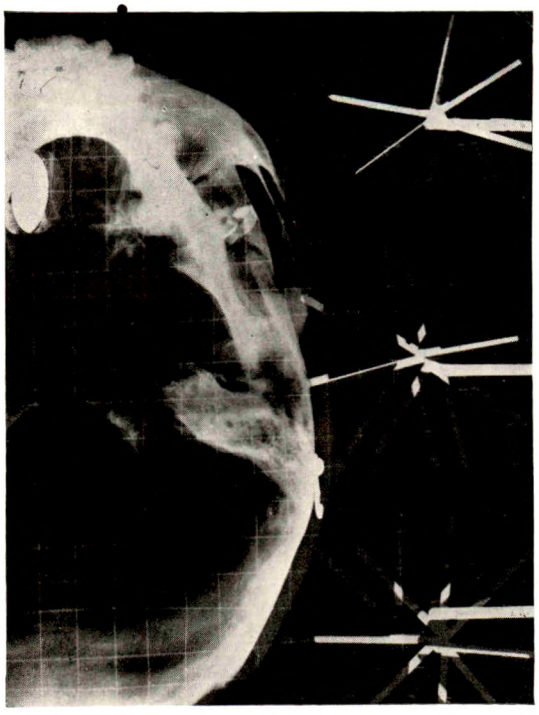


FIG. 4. Two blurred images appear to the naked eye.

2. Now attach a clip to the Wash-Off Relief Film and immerse the film in the developing solution, holding the smooth side to the bottom of the tray. This is done so that the gelatin is not scratched by the bottom of the tray, the gelatin being on the rough side. Agitate gently in the developing solution from one to two minutes. The above steps give an opportunity to exercise further control and to remedy faults of over or under exposure of the original roentgenograms. The developing time is proportionate to the density of the film.

3. The film is next washed in water and quickly immersed in the Wash-Off Relief bath. Agitate vigorously for one minute with the gelatin side facing up so that the tray does not scratch it. This washes off all the undeveloped gelatin and the ordinary lights can then be turned on.

4. Rinse the film in running water to complete the process of washing off the undeveloped gelatin, which may be assisted by gently rubbing with the fingers.

5. Hang this film out of the way and

highly trained technicians nor expensive equipment. Its use is thus not limited to large hospitals. The single-film stereoroentgenogram should have great use at the present time in war surgery. It should accelerate operative procedures by the military surgeon in the field since it can be applied wherever a roentgen-ray unit is carried, it can be taken into forward areas, and it is unaffected by climatic conditions.

Acknowledgment. We wish to express here our appreciation to Dr. Allen T. Newman Dean, New York University, College of Dentistry, for his help in providing facilities, and to Polaroid Corporation of Cambridge, Massachusetts, for supplying materials used in this investigation, and to Surgeon Lieut. Commander John F. M. Milner, Royal Navy, Dr. Miles Atkinson and Mr. John H. Shaw for their helpful cooperation.

PART III

A DEVICE FOR MEASURING DEPTH IN SINGLE-FILM STEREOROENTGENOGRAMS

In the previous part we have shown some of the advantages possessed by the single-film stereoroentgenogram over the conventional double-film stereoroentgenograms in current use. These advantages lie in its simplicity of viewing and making, its cheapness and its universal applicability. But the single-film stereoroentgenogram possesses yet another and even greater advantage than any of these, which is that the depth it portrays can actually be measured, and with great accuracy. By means of a simple device it is possible to calculate the precise depth at which, for instance, a foreign body embedded in the tissues lies from the surface. When the unsatisfactory nature of the present methods of measuring spatial relationships in stereoroentgenograms is borne in mind, it is apparent that this possibility represents a considerable advance.

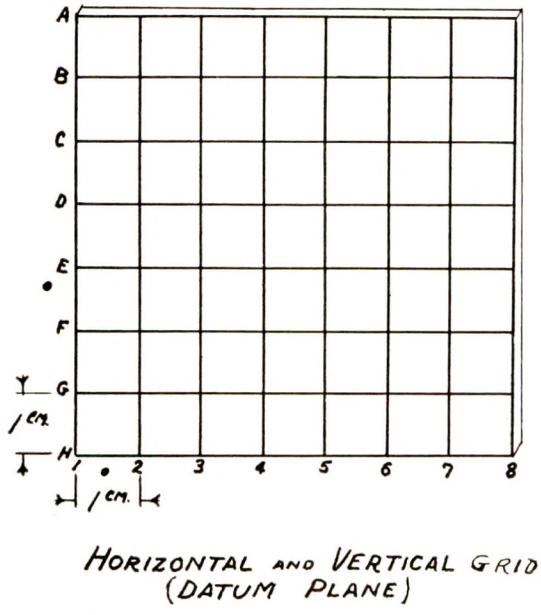


Fig. 5. Horizontal and vertical grid.

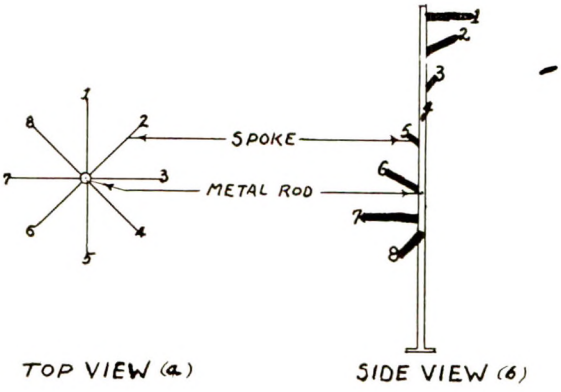


Fig. 6. Vertical depth grid.

The Depth Measuring Grid. The grid which we have devised consists of two parts, a horizontal-vertical and a depth grid.

1. The horizontal-vertical grid is made of a 14 by 17 inch sheet of plastic material transparent to roentgen rays. Embedded in this plastic material are wires, running in a horizontal and vertical direction at distances of 1 cm. apart. The abscissae are designated by letters, the ordinates by numbers, so that any of the squares formed by the crossing wires can be designated (Fig. 5).

2. The depth grid is a long metal rod to which short spokes are attached at right angles and arranged spirally around it (Fig. 6, *a* and *b*). These spokes are spaced at equal distances apart and numbered. Different length grids with different spoke

intervals are necessary according to the size of the object being roentgenographed—hand, chest, etc.—as will be explained later.

The horizontal-vertical grid is incorporated in the cassette and the object to be roentgenographed is placed upon it. The depth grid is attached to the horizontal-

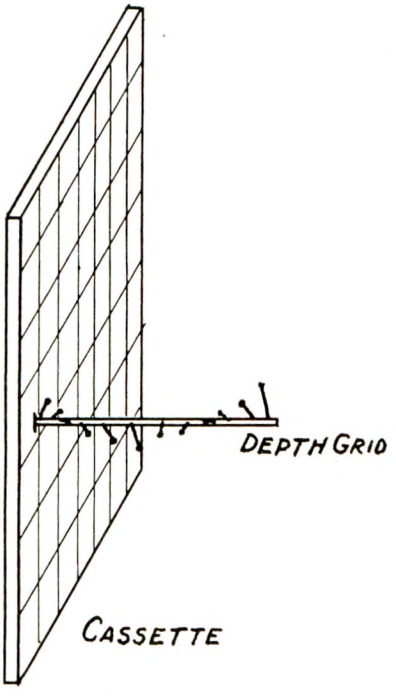


FIG. 7. Depth grid and cassette.

vertical grid at right angles and in contact with the object, thus occupying the third dimension. The resulting roentgenogram shows the images of the object, of the horizontal-vertical grid behind it, and of the depth grid beside it (Fig. 7).

When such a stereoroentgenogram is viewed through the polarizing spectacles, the image of the depth grid will be seen to emerge from the datum plane of the horizontal-vertical grid together with the image of the object. This enables the observer to compare the object-image with the calibrated depth-image since both are in the same stereoptical field (Fig. 8).

Different Sizes and Types of Depth Grid. Different sizes of depth grid must be used according to the part of the body to be roentgenographed—the thicker the part, the coarser the grid. Thus for the hand, a 3 inch long grid with short spokes at small intervals will be suitable, while for the chest, a longer grid with wider spoke spacing will be required. If the foreign body is located between two spokes and more accurate localization is necessary, a finer depth grid can be inserted between these two spokes and another stereoroentgenogram is taken.

We have experimented with several types of depth grid, such as staircase, ladder, concentric circles and continuous spirals. These grids have been applied to special types of work. The depth grid described is the simplest and has been found to be the most generally useful.

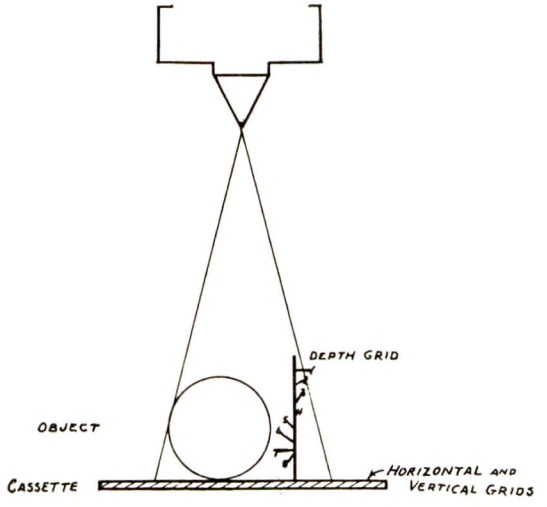


FIG. 8. The horizontal-vertical grid and the depth grid attached to the cassette, object placed in position and roentgenogram taken.

Method of Determining the Position of a Foerign Body.

A. *Lateral Depth.* Obviously this determination is very simple. It is necessary merely to note the square or squares on the horizontal-vertical grid which the foreign body overlies.

B. *Vertical Depth.* There are three methods of calculating vertical depth.

1. By simple observation through the polarizing spectacles, the relationship of the foreign body to one of the numbered spokes can be determined. The distance of that spoke from the horizontal-vertical grid being known, the depth of the foreign body is also known. For instance, if the foreign body is opposite spoke number four, and the spokes are at 1 inch distances on the particular grid in use, the depth of the foreign body from the surface is 4 inches.

2. In order to facilitate this observation, the image of the depth grid in the stereoroentgenogram may be cut off and slid across "into" the object on the stereoroentgenogram, in order to bring the grid closer to the object for easier comparison.

3. This method is mathematically accurate and should be used to check the previous observation, until experience has been gained, particularly for the location of small bodies. Since the stereoptic vision of two observers may differ significantly, the use of this third method employs a polarized ruler. The polarized ruler consists of two transparent polarized sheets 2 by 1 inch, mounted on a 2 inch square of glass. They are secured by scotch tape, one above the other to the glass slab and have their respective fields of polarization at right angles to each other. The junction line, between the two polarized sheets (*A*) and (*B*) as shown in Figure 9, is calibrated in 1/64 of an inch.

Each object appears on the film as two images to the naked eye as in Figure 4. The distance between two shadows of each object is known as the disparity, and this disparity varies with the distance of the object from the eye of the observer. To determine, with mathematical accuracy, the depth of any given object, this disparity must be measured and compared with the disparity of the shadows of the spokes on the grid. The spoke which compares in disparity to the disparity of the object indicates the depth of the object. To determine the grid spoke whose disparity corresponds to that of the foreign body, the polarized ruler is used. First it is slid over the image of the foreign body in the stereoroentgenogram, keeping its calibrated edge parallel to the top of the film. It will then be seen that sheet (*A*) picks up an edge of the foreign body, sheet (*B*) the other edge. The distance between the two is measured with the ruler. Now the ruler is moved over to the grid and slid over the spokes until such a spoke is found, the disparity of which is equal to that measured on the foreign body. That spoke is at the same level as the foreign body.

For greater accuracy of localization, the skin surface should not be used as the base line for measurement, particularly in re-

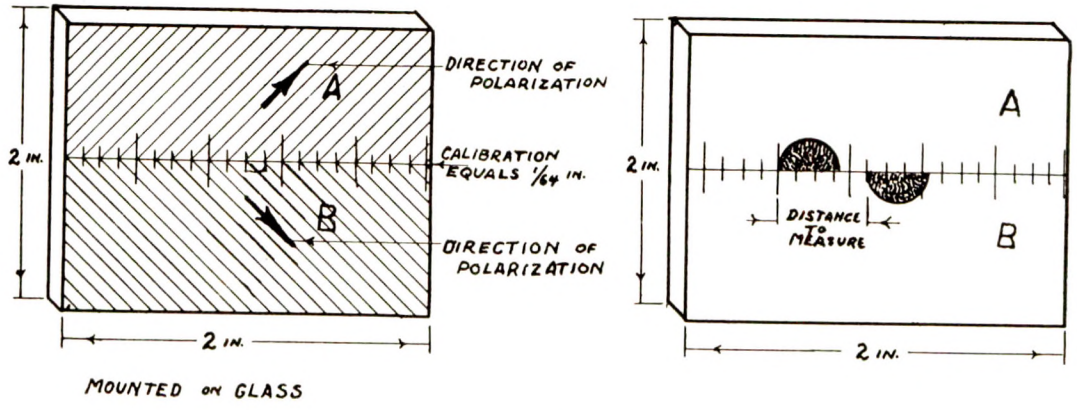


Fig. 9. Polarized ruler.

gions where there is much soft tissue as, for instance, in the thigh. Here the muscle masses are freely movable and compressible, and a reading taken from skin level may be several millimeters out. Instead, a bony landmark should be taken as the base. This landmark, for instance the anterior superior iliac spine, is related to one spoke, the foreign body to another, and the distance between the two is measured, using for determination of each point the polarized ruler described.

Summary. A simple depth grid has been described for the localization of foreign bodies and the determination of spatial relationships.

The method of calculation of depth by means of a polarized ruler has also been described.

The importance of selecting a bony landmark rather than the skin surface for determining the spatial relationship of a foreign body has been pointed out.

2 East 54th St.,
New York, N. Y.

Vol. 49, No. 5

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: Lawrence Reynolds, M.D. *Assistant Editor:* Ruth Bigelow, B.S.

Editorial Board: A. C. Christie, M.D. E. H. Skinner, M.D. Lauriston S. Taylor
Advisory Board for Pathology: James Ewing, M.D. Eugene L. Opie, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this Journal is the official organ, whose names appear on this page, are considered collaborating editors of this Journal. *Foreign Collaborators:* Gösta Forssell, M.D., Stockholm, G. F. Haenisch, M.D., Hamburg, R. Ledoux-Lebard, M.D., Paris.

Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, cancelled.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary,* E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, cancelled.

EDITORIALS

PYELOGRAMS IN ESSENTIAL OR HORMONAL HYPERTENSION

THE experimental animal studies of Goldblatt[1] and other investigators advanced the theory that renal ischemia is a very important causative factor bringing about hypertension through a hormonal activity of a pressor substance formed in the ischemic kidney. Since then many articles have been written dealing with pyelographic examinations of patients exhibiting so-called essential hypertension in an endeavor to find some changes in the pelvis and calices of one or the other kidney with the hope that in such findings a causative factor of renal ischemia might be removed.

Numerous reports dealing with this subject have occurred in the literature. More recently Shrader, Young and Page[2] undertook a study in an attempt to answer certain questions in the interpretation of retrograde pyelograms of hypertensive patients who showed no evidence of "surgical" renal disease. They posed two questions: first, is there a pyelogram characteristic of hypertensives, and second, is the incidence of abnormal urograms in an unselected group of hypertensives greater than in an unselected group of normotensive controls? In an attempt to answer the first question, they limited their study to patients with normal retrograde pyelograms, as judged by well established criteria, and the retrograde pyelograms of one hundred hypertensive patients were compared with the pyelograms of one hundred normotensive individuals.

Their experience gained from urological studies is that the range of normal variations in urograms is much wider than is usually recognized and that questionable pyelographic variations in normotensives are often disregarded while the same variations in hypertensives are emphasized and, as a result of this overemphasis, the patient becomes a "renal" hypertensive.

Any roentgenologist who has the opportunity of seeing a great number of pyelograms done routinely in a urological department is impressed with the wide variations in urograms not only as regards comparison with individuals but often the same individual will exhibit definite normal variations in the pyelographic appearance of the two sides. Therefore it becomes a matter of great importance in fixing the responsibility of a given kidney in a hypertensive case.

Shrader, Young and Page found that hypertension was not associated with any significant variation in the size of the pelvis to the size of the calices, the general configuration of the pelvis, the pelvic axis or the number or morphology of minor calices. They also found that the incidence of hypertension in patients who exhibited easily recognizable renal abnormalities as demonstrated by retrograde pyelograms was 22 per cent. The incidence of significant renal abnormalities in an unselected group of hypertensives was 19 per cent. The retrograde pyelograms of patients with essential hypertension did not differ significantly from those of normotensives, and the incidence of urographic abnormalities in an unselected group of hypertensives appeared to be no greater than in normotensives.

They call particular attention in their

[1] Christian, Henry. Osler's Principles and Practice of Medicine. Fourteenth edition. D. Appleton-Century Co., New York, 1942, p. 1127.

[2] Shrader, J. C., Young, J. M., and Page, I. H. Pyelograms in patients with essential and malignant hypertension. *Am. J. M. Sc.*, April, 1943, *205*, 505–514.

discussion to the dangers inherent in drawing too conclusive opinions from intravenous pyelograms, quoting the words of Wesson and Ruggles: "One who depends upon intravenous pyelograms alone and does not check the diagnosis by a complete kidney investigation is going to make costly blunders."

Master, Marks and Dack,[3] in summarizing the blood pressure readings in 15,000 men and women over the age of forty, came to the conclusion, as was intimated in a former report of theirs, that the incidence of hypertension in the general population over age forty and fifty is higher than is generally appreciated and since hypertension is common in persons over forty, and with the increase in the number of persons surviving this age, the incidence of hypertension becomes an important question. From an analysis of their studies they conclude that the presence of hypertension at age forty and over is so common that a mild degree and perhaps even a moderate degree can no longer be considered abnormal and that the limits of normal blood pressure at these ages should be raised.

The almost constant postmortem findings of renal arteriolar disease in hypertensive patients dying of renal failure has led to a widespread belief that the renal arteriolar disease is the cause of hypertension, whereas there is another group of observers who believe that the arteriolar disease is secondary to the hypertension, the cause of which is still unknown, and there are some observers[4] who believe that the presence of severe arteriolar damage at the end stage of the disease as seen in autopsy material does not necessarily indicate primary arteriolar disease. The most striking result of the recent investigation by Castleman and Smithwick, in which they secured renal biopsies at the time of sympathectomy in one hundred patients, was the finding of such a high percentage of renal biopsies in which there was no or only minimal vascular disease. They came to the conclusion that the morphologic evidence of renal vascular disease in more than half of their cases was inadequate to be the sole factor in producing the hypertension and that in many of these patients and probably others the hypertensive state antedated the renal vascular lesion. They state that their observations are not in keeping with the concept that renal ischemia due to preexisting renal vascular disease is the cause of essential hypertension in man.

It must be plain that the etiological factor in essential or hormonal hypertension is far from established and that the diagnostic deductions which are made from the retrograde ureteropyelographic examinations must be based upon a complete acquaintance with the widespread differences in pyelographic patterns that obtain in the normal and that too hasty conclusions be not drawn from this study alone.

[3] Master, A. M., Marks, H. H., and Dack, S. Hypertension in people over forty. *J. Am. M. Ass.*, April 17, 1943, *121*, 1251–1256.

[4] Castleman, B., and Smithwick, R. H. Relation of vascular disease to the hypertensive state. *J. Am. M. Ass.*, April 17, 1943, *121*, 1256–1261.



EDWARD GEORGE METER
1876–1943

DR. EDWARD GEORGE METER of Reading, Pennsylvania, suffered a coronary attack on March 18, 1943, and died two days later. He was born April 2, 1876, in Wilkes-Barre, Pennsylvania. After two years of the study of medicine under a preceptor in Hazelton, he entered Medico-Chirurgical College in Philadelphia, receiving his M.D. degree in 1897. He began practice in Williamsport, but moved to Reading in 1898.

Dr. Meter's participation in the practice of roentgenology dates back to 1902, when he took up the study at the Univer-

sity of Pennsylvania, and that year he established the department of roentgenology of St. Joseph's Hospital in Reading. He built much of his own equipment. In 1906 he established the department of roentgenology of the Reading Hospital. His membership in the American Roentgen Ray Society dates back to 1903. In 1941 at a dinner tendered him by the Board of Managers of the Reading Hospital celebrating thirty-five years as head of the department, speakers were his contemporary in the Society, Dr. William S. Newcomet; his senior in the Society by one year, Dr. George E. Pfahler; his junior in the society by twelve years, Dr. Francis F. Borzell, then president of the Pennsylvania Medical Society.

Dr. Meter was also a member of the American College of Radiology and of the Berks County and Pennsylvania Medical Societies and the American Medical Association, and he was a past president of the Philadelphia Roentgen Ray Society. When he retired from the active direction of the department of roentgenology of the Reading Hospital he became chief consultant. In addition to his hospital work he had a large private practice, and he was active also in the medical branch of Civilian Defense. For forty years he was a renowned gardener, and his roses and his rock gardens were celebrated. To commune with Nature was one of his great delights, and he was an able botanist.

He is survived by his wife, Marion King Meter, and three children by a former marriage, William J., Dr. Edward G. Meter, Jr., and Florence Meter DeTurck.

RAMSAY SPILLMAN

The Journal regrets to announce the death, on April 23, 1943, of Dr. Cornelius G. Dyke of New York, distinguished roentgenologist and First Vice-President of the American Roentgen Ray Society.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Chicago, Ill., June 6, 1943.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 29–Dec. 3, 1943.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Annual meeting, Brunswick Hotel, Lancaster, Pa., May 15–16, 1943.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Herman Klapproth, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

FIRST INTER-AMERICAN CONGRESS OF RADIOLOGY

The First Inter-American Congress of Radiology is to meet in the Buenos Aires School of Medical Sciences, in October, 1943. *Chairman*, José F. Merlo Gómez, M.D., President of Sociedad Argentina de Radiología; *Secretary*, Oscar F. Noguera, M.D.; *Treasurer*, Manuel F. Terrizzano, M.D.

Purpose. The First Inter-American Congress of Radiology will fulfill a desire which we believe has been entertained by radiologists throughout the Americas. Its sole purpose is to bring together men of science so that they may interchange ideas and tighten friendship bonds.

Radiology occupies an outstanding place within the conception of the unity of medicine. To the era of empiricism of its beginning has followed the present era of progress in which subjects are discussed and dealt with under the brilliant light of truth, of sincerity, for the love of one's neighbor, with the advancement of radiology as a goal.

We meet for this purpose. To this end we are to convene in the First Inter-American Congress of Radiology.

Program. Since the First Inter-American Congress of Radiology will take place some months hence, it is obvious that no final program can be worked out at this time.

Members. In accordance with the general regulations, persons attending the Congress will be registered as members or associate members.

Radiological societies throughout the Americas and, in the lack thereof, professors of radiology or related subjects, heads of radiological departments and associates holding their positions over three years, will be members of the First Inter-American Congress of Radiology. (Although such membership requirements may seem restrictive, their purpose is to induce radiologists to unite into radiological societies—where such societies do not exist—so as to have the opportunity of interchanging ideas and seeking the advancement of their specialty.)

The following will be registered as associate members:

(a) Physicians, physicists, and manufacturers of electromedical apparatus, upon request.

(b) Relatives of members (their wives, sons under eighteen, and single daughters), three such relatives being the limit.

Traveling. To facilitate traveling and lodging to members of the Congress "Exprinter" has been appointed official agency for such purpose, for taking care of customhouse requirements and of such matters as insurance, currency exchange, etc.

Reception. Upon their arrival in Buenos Aires, provided they have announced it, members of the Congress will be met by authorized persons who will tell them how they may reach their lodging place.

Subjects for Discussion.

1. Roentgen diagnosis of diseases of the spine.
2. Cancer of the breast. Treatment and results.
3. Roentgen diagnosis of diseases of the intestine: (*a*) inflammatory jejunoileal affections, (*b*) inflammatory affections of the colon.
4. The teaching of radiology in the Americas.

Visits to Radiological Departments. Several visits will be made in the mornings to radiological departments of the Buenos Aires hospitals. Roentgenograms will be shown, explained and commented on by the department heads during such visits.

Correspondence. Correspondence regarding the Congress should be addressed to Secretaria General del 1er Congreso Interamericano de Radiologia, Alsina 3117, Buenos Aires, Argentina.

MINNESOTA RADIOLOGICAL SOCIETY

Due to the present world conditions, the Minnesota Radiological Society has had no

meetings this year. At the Fourteenth Annual Meeting held in Duluth in conjunction with the Minnesota State Medical Association the following officers were elected: Dr. Arthur U. Desjardins, Rochester, *President;* Dr. John R. McNutt, Duluth, *Vice-President,* and Dr. Annette T. Stenstrom, Minneapolis, *Secretary-Treasurer.* It was decided to hold one meeting a year in conjunction with the meeting of the Minnesota State Medical Association.

AN AID IN CHOLECYSTOGRAPHY

To the Editor:

One of the difficulties encountered in oral cholecystography is the overlying hepatic flexure of the colon, filled either with gas or iodine salts, or both. The use of enemas or drugs is not always successful or desirable in remedying this. Roentgenograms in the erect posture are sometimes successful in separating the vesica fellea from the gut, but this method is not routine in many offices.

I have experimented for some time and have finally succeeded, I believe, in devising a simple and comfortable method to separate the two organs. The preliminary enema is not necessary. One end of an air-filled rubber bag or a hemisphere of balsa wood about 4 inches high is placed under the inferior right costal margin. With the patient prone this displaces the gallbladder upward and the colon downward about 3 to 4 centimeters. While I have not had any personal experience it may well be that small calculi or polyps not visualized by the old method can be seen more easily.

I have had only ten cases in which it was necessary to use this method but in all of them it was simple and easy to displace the gallbladder above the colon, thus making possible a more definite diagnosis.

George Rosenbaum, M.D.

1521 Spruce St.,
Philadelphia, Pa.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

INTESTINAL OBSTRUCTIONS: A PHYSIOLOGICAL AND CLINICAL CONSIDERATION WITH EMPHASIS ON THERAPY; INCLUDING DESCRIPTION OF OPERATIVE PROCEDURES. By Owen H. Wangensteen, B.A., M.D., Ph.D., Professor of Surgery of the University of Minnesota and Surgeon-in-Chief of the University of Minnesota Hospital. Second Edition. Cloth. Price, $7.00. Pp. 484, with 143 illustrations. Springfield, Illinois: Charles C Thomas, 1942.

This book which was first published in 1937 has just appeared in its second edition. The first volume which was an outgrowth of the Samuel D. Gross Prize Award was published under the title "The Therapeutic Problem in Bowel Obstruction." It was enthusiastically received by the medical profession and at once became the standard reference work on the subject of intestinal obstruction. The new volume has been largely rewritten and extensively revised and contains much new material with appropriate illustrations. The work is conveniently divided into four main sections dealing with the following: (1) the fundamental problems of pathological physiology involved in bowel obstruction; (2) the diagnosis of intestinal obstruction; (3) the methods of treatment; (4) the special types of obstruction.

In Part I the author discusses such matters as the mechanisms by which the bowel becomes distended; the nature and source of the contents of the obstructed bowel; the significance of the ileocecal sphincter; the extent of intraenteric pressure and distention upon the bowel wall, the blood supply of the intestine and upon the circulation in general; the consequences of fluid loss and the importance of loss of blood into infarcted intestinal segments in the strangulation obstructions.

Part II consists of a review and summary of the evidence upon which the diagnosis of obstruction rests. The writer discusses the importance of the presence or absence of intestinal colic and of vomiting and the significance of vomiting in small and large bowel obstruction. The roentgen examination is considered in detail and also interpretation and correlation of the roentgen findings with the clinical data. By these several examinations, he believes that it is possible to determine whether obstruction is present, whether it is complete or incomplete, whether the colon or the small intestine is involved and in the latter case whether the obstruction is in the upper, middle or lower portion and finally whether the obstruction is of the simple or strangulation type.

Part III is concerned with the various forms of treatment. Since operation is the mainstay in therapy, the principles and technical features of the acceptable operations are described. The choice of the operative procedure as governed by the character of the obstruction is considered and those obstructions requiring immediate operation are discussed. Considerable space is devoted to the relief of simple mechanical obstruction especially when not complete by suction without operation. Evidence is presented to show a decrease in the incidence of postoperative obstruction consequent upon the more general use of suction during the postoperative period. The indications and contraindications for the use of suction are given and the limitations and shortcomings of this method of treatment are outlined.

One of the most valuable features of the book is the fact that the solution of clinical problems pertaining to the diagnosis and treatment of intestinal obstruction is based upon the important fundamental basic principles of physiology, pathology and chemistry. While abundant use is made of the facts obtained from the basic sciences and from experimental surgery, the book is essentially clinical in character and is designed for the practitioner of surgery rather than for the laboratory worker. In addition to the management of obstructions *per se* adjuvant forms of therapy, e.g., the use of high concentrations of oxygen for distention, the maintenance of fluid nitrogen and electrolyte balance and chemotherapy are dealt with according to their importance. The various surgical procedures are carefully described and well illustrated. Excellent descriptions are given of the aseptic anastomoses long championed by the author

and of the use of the special clamps for this purpose devised by him. The author's personal views concerning certain aspects of the problem are in evidence. Thus, he condemns cecostomy for the relief of acute obstructions of the colon and feels that aseptic transverse colostomy is far superior. He believes that postoperative obstruction at the gastroenteric stoma in gastric resections or gastroenterostomies is almost always the result of technical errors and oversuturing rather than being due to such general causes as hypoproteinemia. With this statement the reviewer is in full accord. The author's method in use at the University of Minnesota Hospital for determining the state of hydration by daily determination of the weight of the patient is presented. When local intraperitoneal implantation of a sulfonamide drug is indicated the author prefers sulfathiazole. In his experience this has proved superior to sulfanilamide.

The use of the Miller-Abbott tube is discussed in some detail and its theoretical advantages elucidated. One of the benefits commonly ascribed to the "long" Miller-Abbott tube is its use in decompression of the intestine prior to resections of the colon. The author's belief that equally good results may be achieved by gastroduodenal suction is shared by many others. While the author was responsible for popularizing gastroenteric suction as a form of therapy, its place, scope and limitations are well defined and operative and non-operative measures are impartially considered. In the opinion of the writer the greatest advances in the future will be in the perfection of surgical procedures whereby the distended bowel may be safely decompressed at operation without peritoneal soiling.

This monograph should occupy an important place in the library of resident surgeons and young surgeons beginning practice and it should also be of inestimable value to the experienced surgeon or any who have occasion to engage in abdominal surgery.

Frederick A. Coller

Roentgen Interpretation. By George W. Holmes, M.D., Roentgenologist to the Massachusetts General Hospital and Clinical Professor of Roentgenology, Harvard Medical School, and Howard E. Ruggles, M.D., Late Roentgenologist to the University of California Hospital and Clinical Professor of Roentgenology, University of California Medical School. Sixth edition, thoroughly revised. Cloth. Price, $5.00. Pp. 364, with 246 illustrations. Philadelphia: Lea & Febiger, 1941.

"Roentgen Interpretation" needs no introduction to older roentgenologists. They have long known it as an excellent text for teaching medical students and for the guidance of those entering the speciality of radiology. The older roentgenologists have known Holmes and Ruggles as pioneers and leaders of their profession, long recognized as leading teachers and living proof of their success in the number of well trained men representing them all over the country. In its sixth edition this book still occupies a leading place among roentgen texts. Earlier editions were written with such insight into fundamentals and such a knowledge of the subject that one is impressed by the many paragraphs which are just as applicable today as they were in previous years. Of course the object of the new edition is to bring the material up to date and this has apparently been done. The book is elementary in its scope but covers the field satisfactorily. It is well written and well arranged and illustrations are plentiful and interesting. Older roentgenologists should enjoy reviewing this new edition. Younger roentgenologists need its help and will find it a firm basis for their roentgen knowledge and will use it for frequent reference. The latter cannot afford to omit this classic text from their library.

E. Walter Hall

Die Deutung des Röntgenschichtbildes der Longenspitzen bei Lungentuberkulose. Von Dr. Wilhelm Kremer, Ärztlicher Direktor der Heilstätten Beelitz und des Tuberkulosekrankenhauses Beelitz (Mark), und Dr. Leonore Retzlaff, Assistenzärztin der Heilstätten Beelitz. Cardboard. Price, RM. 3.60. Pp. 43, with 46 illustrations. Leipzig: Georg Thieme, 1941.

The interpretation of the tomogram of the lungs is not easy and the differentiation between normal blood vessel shadows and cavities is often difficult. The authors undertook, therefore, a comparative study of the tomograms of patients with small lesions in the apex and sections of the fixed lungs prepared after the patient's death; they used the method described by Aschoff. Observations carried out on 5 cases showed that with a pendulum angle of 30 de-

grees the tomograms included a tissue layer of approximately 1.5 cm. in thickness. All foci of pea size could be demonstrated. Cavities in well aerated lung parenchyma of over 1 cm. in diameter are easily seen, also bronchi with thickened walls, emphysematous bullae and bronchiectasis. Some of the diagnostic pitfalls are caused by the anterior arch of the first rib which may simulate a tuberculous infiltration, and also by cross sections of blood vessels which might be mistaken for tuberculous foci. Not every ring-like shadow represents a tuberculous cavity but may be caused by a cyst, bronchiectasis or an emphysematous bulla. With increasing experience the authors believe that tomograms of the lungs can show a picture which corresponds closely to the underlying pathological anatomical process. The illustrations accompanying the text are very instructive and are well worth studying in detail.

ERNST A. POHLE

X-RAY THERAPY OF CHRONIC ARTHRITIS (INCLUDING THE X-RAY DIAGNOSIS OF THE DISEASE): PRELIMINARY REPORT BASED ON 100 PATIENTS TREATED AT QUINCY, ILLINOIS. By Karl Goldhamer, M.D., Associate Roentgenologist, St. Mary's Hospital and Quincy X-Ray and Radium Laboratories; Formerly Roentgenologist, University of Vienna. With a Foreword by Harold Swanberg, B.S., M.D., F.A.C.P., Editor *Mississippi Valley Medical Journal and the Radiologic Review;* Roentgenologist, St. Mary's Hospital and Blessing Hospital, etc. Cloth. Price, $2.00. Pp. 131, with 26 illustrations. Quincy, Illinois: Radiologic Review Publishing Co., 1941.

In this monograph the author relates his experience with the treatment of 100 private patients with chronic arthritis by roentgen rays observed during a period of twenty-one months. He covers the clinical and pathologic aspects of the atrophic and hypertrophic types of chronic arthritis, the roentgen findings, differential diagnosis and the history of roentgen therapy in this disease. He believes that the mechanism of effect is in all probability due to the production of hyperemic stimuli by the irradiation. The indications for and the technique of the treatment are outlined in detail. A table gives in condensed form information regarding age, sex, duration of disease, clinical diagnosis, treated region, roentgen diagnosis and dosage of roentgen radiation. The statistical analysis of the material presented shows that satisfactory results were obtained in about 60 per cent of all patients; the chief benefit was the relief of pain. The author cautions against excessive dosage which would be followed by undesirable sequelae. In conclusion he states that "although the results obtained by us are favorable indeed in a majority of patients (60 per cent), they are not entirely satisfactory because a considerable percentage (40 per cent) are not benefited, or are only slightly benefited, by x-ray therapy. Perhaps when this method of treatment becomes better known and when more physicians become familiar with it and will use it, better results will be obtained."

ERNST A. POHLE

BOOKS RECEIVED

THE PERIODICITY AND CAUSE OF CANCER, LEUKAEMIA AND ALLIED TUMOURS: WITH CHAPTERS ON THEIR TREATMENT. By J. H. Douglas Webster, M.D., F.R.C.P.E., F.F.R., Honorary Director, Meyerstein Institute of Radiotherapy, Middlesex Hospital, London; Lecturer and Examiner in Radiology, University of London, etc. Cloth. Price, $3.50. Pp. 178, with 5 plates. London: Baillière, Tindall and Cox; Baltimore: Williams & Wilkins Co., 1940.

THE ELECTROCARDIOGRAM AND X-RAY CONFIGURATION OF THE HEART. By Arthur M. Master, B.S., M.D., F.A.C.P., Cardiologist to the Mt. Sinai Hospital, New York; Assistant Professor of Clinical Medicine, Columbia University, New York. Second edition, enlarged and thoroughly revised. Cloth. Price, $7.00. Pp. 404, with 163 illustrations, Philadelphia: Lea & Febiger, 1942.

CLINICAL ROENTGENOLOGY OF THE CARDIOVASCULAR SYSTEM. By Hugo Roesler, M.D., F.A.C.P., Associate Professor of Roentgenology and Cardiologist, Department of Medicine, Temple University School of Medicine; Cardiologist, Temple University Hospital, Philadelphia, Pennsylvania. Second edition. Cloth. Price, $7.50. Pp. 480, with 337 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

OLEOPERITONEOGRAFÍA: CONTRIBUCIÓN AL ESTUDIO RADIOLÓGICO DEL PERITONEO. Por los doctores Prof. Carlos H. Niseggi, Professor Adjunto de Radiología de la Facultad de

Medicina de Bs. Aires; Jefe del Servicio Central de Radiología del Hospital Teodoro Alvarez; Miembro Fundador de la Sociedad Argentina de Radiología, Marcelo H. Moreau, Médico Agregado del Servicio Central de Radiología del Hospital Teodoro Alvarez; Miembro Titular de la Sociedad Argentina de Radiología, and Jorge E. Moreau, Médico Interno del Instituto Municipal de Radiología y Fisioterapia. Paper. Pp. 197, with 153 illustrations. Buenos Aires: Libreria y Editorial "El Ateneo," 1941.

NEUROLOGY. By Roy R. Grinker, M.D., Chairman, The Department of Neuropsychiatry of the Michael Reese Hospital, Chicago. Third edition. Revised and largely rewritten. With the Assistance of Norman A. Levy, M.D., Associate Neuropsychiatrist, Michael Reese Hospital, Chicago. With a Chapter on Brain Tumors by Paul C. Bucy, M.D., Professor of Neurology and Neurological Surgery, University of Illinois, College of Medicine, Chicago. Cloth. Price, $6.50. Pp. 1136, with 416 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

A BIBLIOGRAPHY OF AVIATION MEDICINE. By Ebbe Curtis Hoff and John Farquhar Fulton. Prepared for the Committee on Aviation Medicine, Division of Medical Sciences, National Research Council, Acting for the Committee on Medical Research, Office of Scientific Research and Development, Washington, D. C. Cloth. Price, $4.00. Pp. 237. Springfield, Illinois: Charles C Thomas, 1942.

WAR GASES: THEIR IDENTIFICATION AND DECONTAMINATION. By Morris B. Jacobs, Ph.D. Food, Drug and Insecticide Admin. U. S. Dept. of Agr. 1927; Chemist Department of Health, City of New York, 1928; Formerly, Lt. U. S. Chemical Warfare Service Reserve. Cloth. Price, $3.00. Pp. 180, with 8 illustrations and numerous tables. New York: Interscience Publishers, Inc., 1942.

RENAL LITHIASIS. By Charles C. Higgins, M.D., Cleveland Clinic, Cleveland, Ohio. Cloth. Price, $3.00. Pp. 140, with 18 illustrations. Springfield, Illinois: Charles C Thomas, 1943.

TRANSURETHRAL PROSTATECTOMY. By Reed M. Nesbit, M.D., F.A.C.S., Associate Professor of Surgery, University of Michigan Medical School, in charge of the Section of Urology, Department of Surgery. With a Chapter on the Vascular Supply of the Prostate Gland by Rubin H. Flocks, M.D. Cloth. Price, $7.50. Pp. 192, with 62 plates including 94 original drawings by William P. Didusch. Springfield, Illinois: Charles C Thomas, 1943.

SELECTED PAPERS FROM THE ROYAL CANCER HOSPITAL (FREE) AND THE CHESTER BEATTY RESEARCH INSTITUTE. Vol. I. 1935–1939. Paper. Price, 16/-. Pp. 484, with numerous illustrations. London: Royal Cancer Hospital (Free).

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

BENDA, C. E. Observations on the malformation of the head in mongoloid deficiency . . 705

HOWES, W. E., and BERNSTEIN, L.: Oral carcinoma 705

DIGBY, K. H., FOOK, W. L., and CHE, Y. T.: Nasopharyngeal carcinoma 706

GROSS, S. W.: Cerebral arteriography with diodrast 706

REES-JONES, G. F., and MCGIBBON, J. E. G.: Radiological visualization of the eustachian tube 706

GRIER, G. W.: Nasal sinusitis 707

Neck and Chest

POWERS, R. A., and STARKS, D. J.: Acute (primary) coccidioidomycosis 707

RITTERHOFF, R. J.: Acute silicosis occurring in employees of abrasive soap powder industries 708

LEMON, W. S.: Factors involved in production and development of silicotic lesions 708

CLEMENT, G.: Silicosis 708

APFELBACH, G. L., and CARTER, J. B.: Recurrent postoperative atelectasis 708

FARBER, J. E.: Bronchial stenosis and unexpandable lungs 709

JACINTO, C. P., and LAHOZ, M.: "Reversible" and "irreversible" massive pulmonary atelectasis 709

ISRAEL, H. L., and LONG, E. R.: Primary tuberculosis in adolescents and young adults 709

ACKERMAN, L. V., and KASUGA, K.: Chronic cor pulmonale 710

KOERTH, C. J., DONALDSON, J. M., JR., and MCCORKLE, R. G.: Bronchomoniliasis . . . 711

SINGER, J. J., and TRAGERMAN, L. J.: Lipoid pneumonia 711

THOMAS, A. R.: "Blast chest" 712

CRIMM, P. D., COOKSON, H. N., and BROADBENT, M.: Patch and PPD tests and x-ray correlation 712

GOWAR, F. J. S.: Post-operative complications of pulmonary lobectomy 713

GENGENBACH, F. P., and DOBOS, E. I.: Congenital tracheoesophageal fistula 713

SACHS, M. D.: Carcinoma of male breast 713

KORNBLUM, K., and BRADSHAW, H. H.: Intrathoracic neurogenic tumors 714

ODESSKY, I. N.: Roentgen diagnosis of neurinoma of thorax 715

MCGIBBON, J. E. G., and BAKER-BATES, E. T.: Bronchoscopic clinic 715

DOUGLAS, B. H., and BIRKELO, C. C.: Miniature x-ray film of the chest 715

FAULKNER, W. B., JR., RODENBAUGH, F. H., and O'NEILL, J. R.: Influence of emotions upon esophageal function 715

Abdomen

DAVIDSON, S. W., and ROSE, J. D.: Value of cooperation between radiologist and gastroscopist 716

TAYLOR, H.: Practical evaluation of gastroscopy 716

WHITE, J. D.: Unusual sequel to gastroscopy . . 717

COLMERS, R. A.: Parasternal diaphragmatic hernia with report of case on right side . . . 717

DELANO, P. J., RONAYNE, F. J., and BOLAND, T. B.: Rectal dyschezia 717

WASSON, W. W.: Study of gastrointestinal tract of children and its relation to the adult . . . 718

RITVO, M., and MCDONALD, E. J.: Gastrocolic fistula 718

Digby, K. H., Fook, W. L., and Che, Y. T. Nasopharyngeal carcinoma. *Brit. J. Surg.*, April, 1941, *28*, 517–537.

Apparently, judging from the literature, carcinoma of the nasopharynx is not common in other countries, but it is very common in China. Figures from Hong Kong show that it ranks second only to carcinoma of the cervix in number of cases. The only plausible theory to account for this frequency is that of Dobson who says that it is due to irritation from the soot in the small houses which are not ventilated. This hypothesis, however, seems inconsistent with the fact that the disease is much more frequent in men than in women, as women spend more time in the house. Unlike other cancers, this type occurs more frequently before the age of forty than after forty. The age groups in which it is most frequent are those from thirty-one to thirty-five and thirty-six to forty.

The article is profusely illustrated with photographs of patients and photomicrographs of the histopathological findings. The symptoms are extremely varied as the origin of the tumor is near the center of the head and the ear, nose and orbit and all of the cranial nerves and the cervical sympathetic may be affected. The commonest symptom is enlargement of the cervical glands and this is often thought to be syphilitic or tuberculous, and in fact either of these diseases may coexist with nasopharyngeal carcinoma. The association with tuberculosis is particularly frequent because of the appalling prevalence of tuberculosis in Hong Kong. These tumors probably originate from the columnar epithelium lining the upper part of the nasopharynx.

The duration of the disease varies from three months to five years or more without treatment. Treatment has not proved very successful. Owing to the anatomical relations surgery is difficult or impossible. Radium treatment with needles has been tried in 82 cases with some improvement in all; the glands rapidly decrease in size and often disappear but recurrence takes place within six months. No radium bomb has been available for treatment. Deep roentgen treatment would seem to be more hopeful but the authors have not had time to evaluate the results of their deep roentgen therapy. One case at least has proved entirely refractory to this treatment.—*Audrey G. Morgan.*

Gross, Sidney W. Cerebral arteriography with diodrast, fifty per cent. *Radiology*, Oct., 1941, *37*, 487–488.

Diodrast (3, 4-diiodo-4-pyridon-N-acetic acid diethanolamine) has been used for years for intravenous pyelography and more recently for visualization of the heart and great vessels. When it was first tried for cerebral arteriography a 70 per cent solution was injected into the common carotid artery. This caused jacksonian convulsions but when a 35 per cent solution was used good visualization of the cerebral circulation was not obtained.

It has now been found that a 50 per cent diodrast solution gives good visualization without any ill effects. The common carotid artery is isolated from the surrounding structures by passing a narrow vaseline tape under it. The patient's head is put in position for a lateral roentgenogram. The carotid is punctured with a No. 17-gauge needle with a rubber connection. A syringe containing 15 cc. of the solution is attached to the rubber connection and 10 to 12 cc. of the solution injected as rapidly as possible, the film being exposed during the injection. Illustrative arteriograms are given.—*Audrey G. Morgan.*

Rees-Jones, G. F., and McGibbon, John E. G. Radiological visualization of the eustachian tube. *Lancet*, Nov. 29, 1941, *2*, 660–662.

The authors, who are radiologist and aurist at the Royal Air Force Hospital, describe and illustrate their technique for visualizing the eustachian tube. They have used this method only in the examination of the form of deafness that occurs on rapid loss of altitude in flying. The eustachian tube may be regarded as consisting of two cones united at their apices. The outer cartilaginous one is about 24 mm. long and the inner bony one about half as long. The narrowest point in the lumen is where the apices of the two cones join. Here it measures only about 2 by 1 mm.

The opaque medium is introduced through a eustachian catheter passed through the anesthetized nasal fossa and a tympanic catheter pushed through it until it reaches an obstruction. Pyelectan has been found the best medium. Iodized oil is too viscous to pass through the tympanic catheter. In this type of deafness there is a definite block in the cartilaginous part of the tube. Among the authors' 34 cases it was found in 2 at the isthmus, in 1 at 0.5 cm. from the pharyngeal orifice and in the other 31 at 1

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Benda, C. E. Observations on the malformation of the head in mongoloid deficiency. *J. Pediat.*, Dec., 1941, *19*, 800–816.

Mongolism is a fetal disease, occurring in many gradations. It is not a malformation. Many newborn mongolian infants are not recognized due to lack of typical appearance; 2.3 mongoloids occur in every 1,000 births. Mongolism is present in 6 to 10 per cent of mental defectives.

The accepted stigmata of mongolism are epicanthal folds, slanting palpebral fissures, fissured lips and tongue, short hands with curved little fingers, short feet with a gap between first and second toes, stout figure, hypotony, strabismus, deep voice and a typical psychologic behavior. The author has concluded, after a study of 300 mongoloids and 31 autopsies, that the mongoloid appearance is due to growth disorder of the skull. The skull malproportion is only part of a general growth disorder.

In the mongoloid skull the sphenoid body is either upright or bent backward instead of forming its normal angulation with the clivus. The floor of the anterior fossa is steep. The cribriform plate is shorter and lies at a higher level. Failure of development of the facial bones results in persistence of the fetal proportions of the face. The nasion is retracted and the maxilla and mandible underdeveloped. The closure of the fontanelles is delayed. The bones of the skull remain thin and ossification of sutures is delayed or absent. Lack of growth of the spheno-occipital and spheno-ethnoidal synchondroses results in shortening of the base of the skull.

The entire skeleton is involved in the growth disturbance. The length of the metacarpals and phalanges is reduced. Incurving of the little fingers is characteristic.

The delayed growth is now supposed to be due to lack of a specific growth factor, probably from the anterior lobe of the pituitary gland.

The author suggests the term "congenital acromicria" for mongoloid deficiency.—*R. M. Harvey.*

Howes, William E., and Bernstein, Louis. Oral carcinoma. *Radiology*, Oct., 1941, *37*, 468–475.

The authors report 138 cases of cancer of the mouth treated at the Brooklyn Cancer Institute; only 111 are considered in the tabulations as the data were insufficient in the other 27.

Because of the anatomical structure of the mouth with the mucosa in close relation to bone muscles and lymphoid tissue, these cancers develop rapidly and metastasize quickly. Of the authors' cases 63, or 56.8 per cent, were in Stage IV, and only 1, or 0.9 per cent, in Stage I. The patients rarely report for treatment until they have pain from ulceration and infection.

Forty-nine cases, or 44.2 per cent, were in the tongue. They were treated by radium implantation followed by roentgen therapy. The details of the technique are given. Eight of these cases, or 16.3 per cent, were clinically controlled at the time of writing, 1 less than a year after treatment, the rest more than a year and 1 seven years. Of the 16 cases with cancer of the floor of the mouth 2 are alive with the lesions controlled four years after treatment. Three are alive with the disease still active and the others have died. The cases in this series were treated with external irradiation only. A more recent series treated by contact irradiation with the Chaoul type of apparatus seem to be giving better results. All of the 7 patients with cancer of the alveolar ridge are dead, 4 within one year or less, 1 within eighteen months, 1 in two years and 1 in one and a half years. All of the 6 patients who had cancer of the mucous membrane of the cheek are dead, 4 within a year and the other 2 within eighteen months. The 14 patients with cancer of the palate were treated by direct irradiation through an intraoral cone. Seven of these patients are still alive, 2 with evidence of cancer, 5 clinically well after eight months, 1 and a half years, two and a half years, three years and nine years. Only 3 of the 19 cases of cancer of the tonsil appear to be clinically controlled. Two of them have been followed less than two years and 1 just under one year.

Further study is needed to improve methods of radiation treatment.—*Audrey G. Morgan.*

to 2 cm. from the ostium. In these latter sites the pooling of the opaque medium gives mushroom-like shadows.—*Audrey G. Morgan.*

Grier, G. W. Nasal sinusitis. *Radiology*, Dec., 1941, *37*, 659–665.

The roentgen findings in acute and chronic sinusitis and malignant growths involving the sinuses are discussed and illustrated with roentgenograms. Acute catarrhal sinusitis is probably not often recognized because there is little occasion to make roentgen examination of the sinuses in these cases. The author believes that roentgen examination of hay fever patients would show a large percentage of opaque sinuses. In acute suppurative sinusitis the maxillary sinus is most frequently involved though the ethmoid cells or frontal sinus may be affected. The affected cavity appears as a dense uniform shadow. In acute fulminating sinusitis the roentgen diagnosis is complicated by swelling and edema of the soft tissues, which may persist after the cavity is drained and arouse doubt as to whether the pus has been evacuated completely.

In chronic suppurative sinusitis there are confusing factors, such as thickened membranes without sinusitis, that make a history of the case necessary to interpretation of the films and there should be the closest collaboration between rhinologist and roentgenologist. In chronic hyperplastic sinusitis the characteristic findings are caused by the marked edema and swelling of the mucous membrane. The diagnosis depends on the recognition of thickened membrane, polypi or cysts. There are three roentgen signs of polypi: (1) comparatively large, smooth round or pear-shaped discrete shadows; (2) a very thick membrane due to polypoid degeneration; (3) a decided widening of the ethmoid region caused by distention of the ethmoids by the many polypoid growths. In malignant growths diagnosis is based on changes in the surrounding bone rather than any characteristic appearance of the sinuses.

The superior-inferior view is absolutely necessary for visualizing the sphenoid sinus. It does not matter particularly whether it is made from below upward or from above downward. The author prefers to make it from above downward, usually with a Bucky diaphragm. In his routine examination he includes the Granger position. With the patient lying down any pus in the sphenoid gravitates toward the roof. The patient is put on his stomach and the head tilted 17° beyond the horizontal. The shadow of the sphenoid is thrown into the area between the frontals just above the bridge of the nose, and the Granger line, which is the roof of the sphenoid, is seen. If there is pus in the sphenoid this sharp line is not seen.—*Audrey G. Morgan.*

NECK AND CHEST

Powers, Robert A., and Starks, Dorothy J. Acute (primary) coccidioidomycosis: roentgen findings in a group "epidemic." *Radiology*, Oct., 1941, *37*, 448–453.

So-called "valley fever" has long been familiar to the residents of San Joaquin Valley. It is caused by infection with the fungus *Coccidioides immitis* and is usually acquired by inhaling dust which contains the spores. It may occasionally be caused by infection through a skin wound. It is not transmitted from person to person.

In the acute stage the symptoms resemble those of influenza or bronchopneumonia. The second stage shows erythema nodosum, arthritis and conjunctivitis. The clinical diagnosis is made by the finding of typical double-contoured spherules in the sputum, a positive coccidioidin reaction, appearing not earlier than the twenty-sixth day in the authors' group, positive agglutination tests, animal inoculation, leukocytosis and eosinophilia. In a series of acute cases studied in California the fatal granulomatous form developed in only one, in this case in the form of meningitis.

The authors had an opportunity to make roentgen examinations in a group of 7 students who acquired the infection on a field trip to an endemic region. The cases are described and illustrated with roentgenograms. Generally the lesions are solitary or few in number and consist of spherical opaque areas with a peripheral distribution. They are usually opposite or posterior to the hilum, in the lower part of the upper lobe or the upper part of the lower lobe. The findings resemble those of pneumonia or primary tuberculosis. In the few cases with multiple lesions the picture may resemble that of cancer. It is doubtful whether acute coccidioidomycosis can be diagnosed by roentgen examination alone but the findings may be characteristic enough to suggest the right diagnosis which may be confirmed by finding eosinophilia, spherules in the sputum and later the positive coccidioidin test and agglutination reaction.—*Audrey G. Morgan.*

RITTERHOFF, R. J. Acute silicosis occurring in employees of abrasive soap powder industries. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 117–131.

Acute silicosis has been reported for various types of abrasive contacts though very few have been employed in soap factories. The author is reporting 2 cases in soap workers.

The exposure times for these 2 cases were one hundred days and twelve months, respectively—much less than the duration of contact for cases of similar type. The duration of life following recognition of the disease was longer than reported for these other cases, it being four years as an average for the 2 cases.

The factor of alkalinity is mentioned as possibly explaining the rapidity in development of the fibrosis.

When tuberculosis occurs in this type of case it has usually been of the exudative caseous type.

"Metastatic" silicotic lesions were found in 1 of the 2 cases. These are described as "foci of macrophages which do not show the typical histology of silicotic nodules and may be areas of reticulo-endothelial hyperplasia rather than true metastasis."

One of the 2 cases showed a cor pulmonale—as in 3 of 9 similar cases reported in the literature—apparently not an infrequent complication which is most prone to develop in cases having areas of massive fibrosis and marked emphysema.—*A. A. de Lorimier.*

LEMON, WILLIS S. Factors involved in the production and development of silicotic lesions. *Radiology*, Oct., 1941, *37*, 413–420.

The author describes silicosis produced by the introduction of silica dust into the lungs of rabbits by intubation or by its intraperitoneal injection. No other dusts are so damaging as silica. The reaction between the particles of silica and the tissue cells results in fibrosis. Fibrosis is brought about by arrest of the phagocytes after the particles have been phagocytosed. The formation of the fibrous nodule represents an effort on the part of the body to segregate and encapsulate the noxious material so that it may do the least possible harm to respiratory function. Simple uninfected silicosis affects respiratory function in proportion to the amount of fibrous tissue that develops, the consequent reduction of vital capacity and the resultant failure of the right heart. The lungs of their experimental animals resembled those of old Cornish miners who were dyspneic and cyanotic as a result of strain on the right side of the heart.

If the lung becomes infected it increases fibrosis in the lung parenchyma around the nodules, produces ulceration and necrosis of bronchi and blood vessels and causes death of the animal from bronchitis, bronchopneumonia and empyema. The changes are similar to those seen in tuberculosilicosis in human beings or even in simple fibrocaseous tuberculosis.—*Audrey G. Morgan.*

CLEMENT, GAGE. Silicosis. *Radiology*, Oct., 1941, *37*, 407–412.

As a result of personal observation in the mines of the north central part of the United States, the author claims that simple silicosis is not a disease, it is not disabling and does not cause death. He says that silicosis does not predispose to tuberculosis. He presents roentgenograms which he claims support his contention. He says that silicosis causes no abnormal picture in the lungs except discrete nodulation and that any other abnormality is evidence of disease that is not caused by the silicosis.

Dr. Rigler said in the discussion that the extent of findings in the roentgenogram does not show the degree of disability in silicotics. He has seen 3 autopsies in the past three years in which the subjects had no evidence of any other pathological condition except silicosis and they died from this condition—or as he prefers to call it—this disease. He believes that silicosis does predispose to tuberculosis and cites the work of Lanza and the statistics of the Metropolitan Life Insurance Company in support of this opinion.—*Audrey G. Morgan.*

APFELBACH, GEORGE L., and CARTER, J. BAILEY. Recurrent postoperative atelectasis. *Radiology*, Nov., 1941, *37*, 598–603.

The first case of postoperative atelectasis reported was probably that of Barr in 1907. Elliott and Dingley in 1914 first put forth the theory that it is caused by obstruction of the bronchi by secretion. But there is considerable evidence against the truth of this theory. Cases have been described in which there was no obstruction of the bronchi, and a reflex via the vagus has now been suggested as the cause of this atelectasis. A case is described which lends support to this theory.

A first-stage Torek operation was performed on a boy of ten for cryptorchidism August 22, 1938. Eighty hours after operation his temperature rose to 104° F. and the diagnosis of atelectasis made from the clinical symptoms was confirmed by roentgen examination. He was made comfortable by postural treatment and his condition gradually returned to normal, though the atelectasis did not disappear completely for two weeks. On May 1, 1939, the second stage of the Torek operation was performed and because of the history the greatest care was used. The anesthetic was ethylene, as in the previous operation. On the fifth day after operation he showed weak, irregular pulse and high fever. The diagnosis of atelectasis was confirmed as before by roentgen examination. As before two weeks was required for complete disappearance of the atelectasis.

This case warrants a further study of the problem from the point of view of the vegetative nervous system with the object of using vago-sympathetic block for the prevention of post-operative atelectasis.—*Audrey G. Morgan.*

Farber, Jason E. Bronchial stenosis and unexpandable lungs. *Am. Rev. Tuberc.*, June, 1941, *43*, 779–784.

Occlusion of a bronchus can be expected to produce atelectasis followed by irreparable pathological changes. This might result because of an ulcerative tuberculous tracheobronchitis and even because of a stenotic but non-occlusive peribronchial tuberculous process leading to pneumonitis and extensive fibrosis.

A case of the latter type is described. Bronchial asthma was the predominant symptom. Tubercle bacilli were isolated and a therapeutic pneumothorax was performed on the left lung. The clinical course was characterized by intermittent attacks of fever and episodes of copious expectoration with relief of toxicity. After several years of negative sputa, attempts were made to re-expand the lung but without success. Repeated bronchoscopic examinations revealed a bronchial opening of only a few millimeters at a site where there was considerable exudation.

A second case presented similar clinical manifestations with asthma and copious purulent expectoration. Tubercle bacilli could not be found in the sputum. Again, bronchoscopic examinations revealed a very minute lumen for the left main bronchus. Dilatation could not be accomplished.—*A. A. de Lorimier.*

Jacinto, Carmelo P., and Lahoz, Manuel. "Reversible" and "irreversible" massive pulmonary atelectasis: A radiologic study. *Radiology*, Nov., 1941, *37*, 588–597.

The authors made a roentgen study of massive pulmonary atelectasis at the Quezon Institute for Tuberculosis in Manila. They classify the cases as reversible or irreversible depending on whether or not it is possible for the lungs to be re-aerated. Reversible atelectasis is apt to be caused by blood clots or tenacious secretions in the bronchi while the irreversible type is largely caused by tracheobronchial tuberculosis, though it may occur suddenly during or after anesthesia.

The authors describe 4 cases and illustrate them with roentgenograms. They use serial teleroentgenograms or tomographic exposures in these cases; the latter are especially useful in differentiating between pleural and pulmonary opacities. About 5 mm. of the chest is within focus during each tomographic exposure and the plane in focus is pictured so clearly that it is easy to see the condition of the lung parenchyma.

Three of the cases reported were irreversible atelectasis, 1 of them non-tuberculous and caused by a bronchogenic tumor. Dyspnea was not a prominent symptom in these cases while in the 1 reported case of reversible atelectasis dyspnea was a very striking feature. This case was one of massive atelectasis of the entire lung in a Filipino. It was probably caused by blood clots after hemoptysis in tuberculosis. The dyspnea in this case was partially relieved by repeated insufflations of air into the left pleural cavity. Massive pulmonary atelectasis in Filipinos is not as rare as is generally believed. Of course it is harder to diagnose the reversible than the irreversible type because it is temporary. Cavities may occur in an area of atelectasis.—*Audrey G. Morgan.*

Israel, Harold L., and Long, Esmond R. Primary tuberculosis in adolescents and young adults. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 42–55.

The age of onset of the primary phase of tuberculosis is changing, a larger and larger number showing lesions in adolescent or adult life. There appears to be a difference of opinion as to the seriousness of the lesions occurring at these later years. Some consider the resistance to be identical to that of childhood; others speak of

variations in the character of the lesions and much more serious prognoses.

Reference is made to the progressive changes as described in the second edition of "Diagnostic Standards"; in particular, to the most recent expression: "It is not always possible on clinical and roentgenological evidence to differentiate primary and re-infection phases of tuberculosis."

For this reason a number of cases of the Phipps Institute have been carefully studied with particular interest in the relationship of the tuberculin test to one or another type of lesion.

A relatively small proportion developed primary lesions during adolescence. Of those who did, it was very infrequent that clinical tuberculosis occurred within one year of the change from negative to positive skin reaction. In most instances, the time interval was greater than one year—thereby lending to the explanation that such cases represented a reinfection process.

A variety of types of lesion were found in those showing pulmonary changes within the one year of positive skin reaction—cases therefore considered as of the primary phase. The Negro group showed the greatest tendency toward lymphadenopathy, and the "typical" picture of childhood lesions. Lymph node enlargements among Negroes appear to be common regardless of the age of the individual

There was only 1 case of acute miliary tuberculosis. Loss of tuberculin sensitivity appears to be decreasing. The progress of lesions is frequently indeterminate, in 1 case a typical primary reaction leading to a progressive involution; in another, to a fulminating course. The majority of infiltrations appear to develop at least one year after the last negative tuberculin test.

The distinction between primary and reinfection disease will rarely be a useful guide in estimating prognosis or in planning treatment for the individual case.—*A. A. de Lorimier.*

Ackerman, Lauren V., and Kasuga, Kazumi. Chronic cor pulmonale; its relation to pulmonary tuberculosis. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 11–30.

Acute cor pulmonale is usually caused by a large pulmonary embolus or it is secondary to disease of the left heart. It is characterized by sudden onset of cyanosis, low blood pressure and possibly by a state of actual shock. The manifestations may simulate acute coronary occlusion or spontaneous pneumothorax. Roentgenographically, there can be expected to be evidence of dilatation of the pulmonary arteries and enlargement in the region of the conus.

Subacute cor pulmonale has been considered as identical to these. However, Brill has suggested that the subacute type is due to plugging of the lymphatics of the lung such as might be produced by metastatic carcinoma arising from the stomach. It is theorized that such plugging may cause irritation about the contiguous pulmonary arteries with resultant formation of small thrombi and hypertension in the pulmonary circulation.

Chronic cor pulmonale may be secondary to left sided failure or it may be due to changes in the arterial system of the lung or to alterations in the pulmonary parenchyma or thoracic cage. The first of these is the most common, the changes being secondary to aortic insufficiency, mitral stenosis, coronary disease and even to beri-beri, etc. As far as changes in the vascular bed are concerned, thromboses may occur in sickle cell anemia, primary sclerosis, necrotizing arteritis, etc. Alterations in the parenchyma include bronchiectasis, silicosis, bronchogenic carcinoma or any other disease of widespread involvement.

This report is concerned particularly with the chronic type and especially with pulmonary tuberculosis as the contributing factor. The incidence of hypertrophy of the right heart has been reported variously by different observers—from less than 0.1 per cent to as high as 33 per cent in cases of pulmonary tuberculosis.

Identifying symptoms may be meager. Roentgenography should include posteroanterior, oblique and lateral projections. The electrocardiogram may show right axis deviation or no abnormality. Diodrast injections may be most informative. Tomography may be informative. In early cases the use of ether and decholin or other drugs may be indicated to establish prolongation of the circulation time from the arm to the lung. In the more advanced cases there may be paroxysmal nocturnal dyspnea with Cheyne-Stokes breathing, cyanosis, distention of cervical veins, enlargement of the liver and spleen, ascites and edema of the lower extremities.

Pathologically, the wall of the right ventricle may be found to measure as much as 5 mm. in thickness. It may even be thicker than the left

ventricle. The heart may weigh 250 to 500 grams. The pulmonary arteries may show periarterial fibrosis and atherosclerosis or subintimal fibrosis, atrophy of the media and increase in the elastic tissues of the intima and adventitia.

Of a group of 330 autopsies concerned with patients of the San Francisco City and County Hospital, 16 per cent showed cor pulmonale. Obliteration of pleural space was of frequent incidence among the entire group though it did not seem to be a definite factor.

The existence of this condition should be considered before instituting any type of collapse therapy for the added embarrassment of collapse may result in sudden or early death.

Death occurs earlier in cases of tuberculosis complicated by silicosis or anthracosilicosis as compared with cases of any one of these conditions, alone. Heart failure is the common terminal factor.

In chronic miliary tuberculosis there may be a diffuse fibrosis through the interstitial tissues with right heart enlargement but more commonly a miliary lesion is too rapid in development to present the heart changes.

The authors conclude that the evidence of cor pulmonale is relatively low in uncomplicated pulmonary tuberculosis. It tends to develop in a chronic productive tuberculosis of long standing where there is a secondary emphysema; in chronic productive miliary tuberculosis and in pulmonary lesions complicated by silicosis or anthracosilicosis. Pneumothorax or long standing and markedly thickened pleurae may produce it, as may also thoracoplasty. The existence of other cardiac pathologic conditions can be expected to hasten the development of it.—*A. A. de Lorimier.*

Koerth, C. J., Donaldson, J. M., Jr., and McCorkle, R. G. Bronchomoniliasis. *Am. Rev. Tuberc.*, June, 1941, *43*, 723–737.

In 1905, Castellani described primary bronchomoniliasis in a "tea taster" of Ceylon, India. Subsequent reports indicate a substantial incidence of such infection. Keiper, for instance, estimates that 3 per cent of apparently normal individuals harbor monilia in their throats and that 2.93 per cent of pulmonary disease is due to these organisms. It is more common in tropical and subtropical climates but masquerades as tuberculosis in all latitudes.

Two such cases are reported in detail.

The diagnosis is dependent upon isolating the organism from sputum which is definitely expectorated from the lungs. The mouth should be cleansed well prior to collecting a specimen. Usually a culture is necessary. The value of inoculation of the isolated organism into animals such as the rabbit is disputed. Skin testing with such organisms appears to be of greater reliability. Agglutination tests are believed to be impractical. Complement fixation tests may be indicative. Particularly in cases which have developed an allergy to the monilia, there may be an appreciable eosinophilia.

Roentgen studies may be negative or they may show peribronchial thickenings, areas of infiltration, consolidations, fibrosis, pleural thickening or scattered nodules throughout the lung fields. The criteria of pulmonary tuberculosis may be duplicated except that in monilia involvements of the lung, the apices are usually clear. Moreover, in the latter, the lesions are likely to manifest migratory tendencies.

Pathologically, there may be found consolidations, cavitations, fibroses and tubercles. Microscopically, the alveolar walls may appear thickened, the tubercles may show a caseous center surrounded by epithelioid cells, lymphocytes and an occasional giant cell.

Treatment consists of potassium iodide given in dosages of 5 drops, three times a day, increased as tolerated up to 30 drops three times a day. Of course, tuberculosis should be ruled out before instituting such treatment. The iodide therapy may be supplemented by subcutaneous injections of autogenous vaccines. Other treatment includes pix liquida (1 gram or more a day), thymol (given orally), gentian violet or methylene blue (given intravenously). Roentgen therapy has given fair results. Intratracheal and intramuscular injections have been recommended for severe cases.—*A. A. de Lorimier.*

Singer, J. J., and Tragerman, L. J. Lipoid pneumonia; report of a case simulating bronchial carcinoma. *Am. Rev. Tuberc.*, June, 1941, *43*, 738–747.

Oil pneumonias are of interest particularly because of the bizarre pictures which they may produce and because they are so seldom suspected. They are found especially during the first months or years of life and in old age or in the very debilitated.

The case reported is of a physician who for several years had been taking mineral oil be-

cause of constipation. The disease picture was considered a pulmonary cancer. His trouble developed with a coronary attack following which he had experienced difficulty in swallowing. At intervals, he became febrile and expectorated blood streaked sputum. Roentgenography of the chest prompted a diagnosis of lymphatic carcinomatosis. One consideration was of silicosis. Because of loss of weight, hemoptysis, weakness and pain over the chest, carcinoma seemed the more likely. After a period of three years he had lost 66 pounds. He could not sleep and he suffered marked dyspnea. Various studies were refused because the doctor had been told that he had a carcinoma and he was certain of the diagnosis.

During the last year, he developed ascites, anasarca and right heart failure—secondary to emphysema, bronchiectasis and diffuse pulmonary fibrocystic changes with multiple abscesses. His temperature reached 104° F.

The authors emphasize that though there be no known treatment for lipoid pneumonia, it is important that the administration of oils be discontinued as early as possible. This case, along with others, emphasizes the importance of accomplishing a complete study in all chest problems. Lipoid pneumonia should be suspected whenever there is a dysphagia in one using oil. The presence of oil droplets in the sputum may support the diagnosis though such evidence may be lacking unless bronchoscopy is accomplished.—*A. A. de Lorimier.*

THOMAS, A. ROBINSON. "Blast chest"; radiological aspect of the pulmonary changes following exposure to high pressure waves. *Brit. J. Radiol.*, Dec., 1941, *14*, 403–406.

Cases of what is called "blast chest" are described and illustrated with roentgenograms. They are caused by waves of high pressure from explosives and a number of them have been seen since the beginning of the war. The chief roentgen finding is an opacity of the lung, which varies in degree depending on the severity of the lesion. The ribs over the affected area are crowded together behind and widely separated in front, that is they are in a position of hyperexpansion. It is hard to get good roentgenograms of these cases as the patients are usually confined to bed and often have severe burns or lacerations so that they have to be examined in bed with portable apparatus. There are few clinical signs in mild cases except a ballooning due to the hyperexpansion. The opacity is caused by hemorrhage into the lung, and therefore it is important for physicians to know that roentgen examination should be done in these cases, as otherwise serious injuries may go undetected.—*Audrey G. Morgan.*

CRIMM, PAUL D., COOKSON, H. N., and BROADBENT, M. Patch and PPD tests and x-ray correlation. *Am. Rev. Tuberc.*, June, 1941, *43*, 799–805.

In an Indiana section 1,556 high school freshman were studied with patch tests, intracutaneous tests and roentgen examinations. The intracutaneous testing was made with a dosage of 0.001 mg. as the routine. The injections were made in the left arm and the patch tests were applied to the right arm (after cleansing and defatting with acetone). Readings were made after forty-eight hours and again after seven days. The intracutaneous tests were reported positive when there was redness with induration. The patch test was considered positive in the presence of follicles on an erythematous indurated base.

The incidence of contact was 10.7 per cent; 29.9 per cent showed positive evidence roentgenologically or by one or the other skin tests. There were no definite cases of reinfection though 7 showed some fibrosis; 15.8 per cent were positive to the patch test; 16.3 per cent, to the intracutaneous inoculation. Fourteen were negative to the patch test and positive to the intracutaneous test while 7 were positive to the patch test and negative to the intracutaneous test.

Considering the entire group which showed evidence of one sort or another, the 29.9 per cent, 19.7 per cent showed positive roentgen evidence; 16.7 per cent, positive tuberculin testing; 6.2 per cent were positive both to roentgen ray and the tuberculin; 13.2 per cent were negative to both tuberculins but showed positive roentgen evidence; 10.2 per cent were positive to the tuberculins and negative roentgenologically. Sixty-five and nine-tenths per cent of the total group who showed any positive evidence showed roentgen evidence while 56 per cent were positive to the tuberculins—an efficiency for roentgen examination over the tuberculins of 9.9 per cent.

Previous studies of an adult group indicated that tuberculin testing was 2.2 per cent more effective than roentgen examination. The effi-

were collected with pathological data in 178. In addition to these cases 172 from the literature were analyzed.

In this series the ratio of male carcinomas to all carcinomas in the male was 0.38 per cent and that to cancers in the female breast 1.32 per cent. The average age was 57.17 years, the youngest patient being twelve years of age and the oldest eighty-six years. The average in the male is older than in the female. The average time between the beginning of symptoms and the first consultation of a physician was 1.14 years. Sixty-one per cent of the patients consulted a doctor within a year of the beginning of symptoms and 87.2 per cent within two years

There was retraction of the nipple in 33.1 per cent of the cases, pain in 38.1 per cent, bleeding nipple in 14.6 per cent, ulceration in 20.6 per cent; there was a history of trauma in 23.9 per cent of the cases. The carcinoma was bilateral in 3 cases, in the right breast in 99 and in the left breast in 103.

The histopathological findings are practically the same in cancer of the male breast as in that of the female breast. The prevailing types are adenocarcinoma, scirrhous carcinoma, medullary carcinoma and carcinoma simplex. Sarcoma, squamous cell and basal cell carcinomas are rare. Wainwright said that he could not differentiate in histopathological studies between male and female carcinoma.

There was local recurrence in 25.9 per cent of these cases, distant metastases in 46.3 per cent. Postmortem examinations were done in 24 of this series of cases and 17 from the literature. They showed metastases in the lungs in 62.5 per cent, in the ribs and axillae 29.17 per cent, pleura 33.33 per cent, spine 25 per cent, pelvis and generalized metastases 20.83 per cent.

Simple mastectomy was performed in 21 per cent of the author's cases, total mastectomy in 44 per cent. Roentgen treatment was given in 53 per cent. Among these cases 23.8 per cent were given preoperative roentgen treatment, 55.1 per cent postoperative and 21.1 per cent palliative treatment.

The prognosis is bad in cancer of the male breast. Fifty-two per cent of these patients were dead within five years, though most of them had been given adequate surgical and roentgen treatment; 7.5 per cent were living and well at the end of that period; 7 per cent were living with recurrence after from five to ten years; 3 per cent were living and well after ten to fifteen years and 2.9 per cent were living after from sixteen to twenty years.—*Audrey G. Morgan.*

Kornblum, Karl, and Bradshaw, Howard H. Intrathoracic neurogenic tumors. *Radiology*, Oct., 1941, *37*, 391–406.

Intrathoracic neurogenic tumors are commonly believed to be quite rare but the authors have seen 7 cases within the past four years in addition to one malignant metastasis which was mistakenly diagnosed as a neurogenic tumor. The only clinical symptoms from these tumors are pressure symptoms and their nature depends on the organs on which pressure is being exerted. They are of little value in diagnosis. A rapid course and marked loss of weight suggest malignancy. The most valuable method of diagnosis therefore is roentgen examination and many of these tumors are discovered accidentally on routine roentgen examination.

The authors' 7 cases, consisting of 4 neurofibromas and 3 malignant neurogenic tumors, are described and characteristic roentgenograms given. In only 1 of these cases was the correct diagnosis made by roentgen examination, and yet the appearance is so typical that diagnosis should not be difficult. Most of them are in the posterior part of the chest and a dense, rounded, well circumscribed shadow in the posterior part of the chest of considerable size should suggest such a tumor. It is remarkable to what a large size they can grow without causing clinical symptoms. A fluoroscopic examination should first be made with the patient in all possible positions in order to show the effect of the tumor on respiration and heart action and the position of the diaphragm and its movements. Roentgenograms should be taken in anteroposterior, lateral and oblique positions. As neurogenic tumors are generally in the posterior part of the chest the lateral view is particularly important. Stereoscopic films are often of value. Films made with the Potter-Bucky diaphragm should be a part of the routine examination. The use of iodized oil is not of much value but an examination after artificial pneumothorax often gives valuable information.

The only treatment is surgical. These tumors are very resistant to irradiation and therefore in benign cases roentgen treatment is of no value. In malignant cases it may relieve the symptoms. In 2 of the authors' cases of neurofibroma the surgical results were excellent, in 1

ciency of the tuberculin test increases up to the age of fifty years when it decreases due to probable loss of allergy. Re-examinations with higher dosage of P.P.D. (0.005 mg.) increased the efficiency 3.6 per cent.

The authors conclude that the patch test may safely supplant the intracutaneous test although they admit difficulty of reading the former in colored subjects.—*A. A. de Lorimier.*

GOWAR, F. J. SAMBROOK. The post-operative complications of pulmonary lobectomy; clinical and experimental study. *Brit. J. Surg.*, July, 1941, *29*, 3–18.

In spite of improvements in surgical technique pulmonary lobectomy for bronchiectasis still shows a mortality of 10 to 20 per cent. In an attempt to determine the causes of the complications following this operation and if possible find means of preventing them, the author reviews 154 cases operated on at the Brompton Hospital from 1929 to 1938.

The complications that may occur are shock, reactionary hemorrhage, tension pneumothorax, embolism, intracardiac thrombosis, massive collapse of the remaining lobe, bronchopneumonia, infection, pericarditis and spread of the bronchiectasis. Collapse of the remaining lobe is by far the most serious complication and was responsible for more than one-third of the postoperative deaths in this series. Illustrative roentgenograms are given. Collapse occurs much more frequently if the lobe is free and therefore the best means of preventing it is to bring about adhesions between the upper lobe and the chest wall. This can be done by insufflating iodized talcum powder into the pleural cavity. This method is harmless if the powder is efficiently sterilized. The ideal time for operation is three to eight weeks after the insufflation while the adhesions are still soft.

Other precautions that may be used to decrease the danger of lobectomy are: allowing a long period of postural drainage after operation in order to reduce the amount of sputum; encouraging the elimination of the contrast medium after bronchography, and, if there is much roentgen evidence of retention, allowing an interval of at least two months between bronchography and lobectomy; using spinal anesthesia; provision of adequate drainage and taking care to see that it does not become blocked; encouragement of postural drainage of the upper lobe by placing the patient in a semi-sitting position as soon as possible after the operation; encouragement of re-expansion of the upper lobe by breathing exercises and if necessary by intermittent inhalations of CO_2 and oxygen.—*Audrey G. Morgan.*

GENGENBACH, F. P., and DOBOS, E. I. Congenital tracheoesophageal fistula. *J. Pediat.*, Nov., 1941, *19*, 644–655.

Tracheoesophageal fistula is usually found in association with atresia of the esophagus. These fistulae invariably occur at or close to the bifurcation of the trachea. Embryologically the trachea and esophagus appear to arise from a common entodermal pouch situated in the thorax behind the heart. Lateral grooves appear in this pouch when the embryo has reached a length of 4 mm. and these eventually meet in the center to form a septum which divides the entodermal pouch into a posterior tube belonging to the alimentary system and an anterior tube belonging to the respiratory system. Tracheoesophageal fistulae represent incomplete development of this septum.

Vogt has divided congenital atresia of the esophagus into three types: (*a*) complete absence of the esophagus; (*b*) the esophagus is divided into an upper and lower pouch with no communication, and (*c*) cases with fistulous tracts between the esophageal pouches and the trachea.

The diagnosis of tracheoesophageal fistula has been made by injecting barium, or better iodized oil, into the esophagus through a small catheter. Recently Lanman has advised that this is potentially harmful and unnecessary. He feels that the diagnosis can be made by inserting a soft rubber catheter into the esophagus and exposing a film. The only hope for ultimate survival of the infant lies in surgery in the first few days of life. Otherwise an aspiration pneumonia is certain to result.

The author concludes his article with case reports of 10 infants. In the majority the diagnosis was made or at least suggested by roentgen examination following barium or iodized oil ingestion.—*R. M. Harvey.*

SACHS, MAURICE D. Carcinoma of the male breast. *Radiology*, Oct., 1941, *37*, 458–467.

A questionnaire on carcinoma of the male breast was sent to a large number of pathologists, radiologists and surgeons in the United States and Canada and records of 208 cases

the patient died suddenly from peritoneoscopy and in 1 of neurofibroma of the esophagus the patient died four days after operation. Diagnosis is difficult in such unusual sites.—*Audrey G. Morgan.*

ODESSKY, I. N. The roentgen diagnosis of neurinoma of the thorax. *Radiology*, Oct., 1941, *37*, 454–457.

The author reports from Moscow a case of neurinoma of the wall of the chest in a woman of thirty-seven who had been sent in with a diagnosis of echinococcus cyst of the lung. Roentgen examination showed an oval homogeneous shadow in the upper part of the left lung measuring 7×4 cm. close to the chest wall. It appeared to lie outside the lung which was otherwise unchanged. There was no interference with the excursion of the diaphragm. On the basis of the clinical and roentgen findings a probable diagnosis of encapsulated exudative pleurisy was made. Operation showed a tumor which histological examination proved to be a neurinoma.

These tumors of the chest wall are rare. The roentgen appearance may resemble that of encapsulated pleurisy or metastatic tumor. If the roentgen picture remains constant over a long period and the patient's general condition is good it suggests neurinoma. If there are neurofibromatous lesions of the skin or elsewhere it supports this diagnosis.—*Audrey G. Morgan.*

MCGIBBON, JOHN E.G. and BAKER-BATES, E.T. A bronchoscopic clinic. *Brit. J. Surg.*, Jan., 1941, *28*, 404–414.

The authors, who are laryngological surgeon and physician to the Royal United Liverpool Hospital, established a bronchoscopic clinic six years ago. It has been held once weekly and it has been found that the maximum number of patients that can be examined at a session of four. Up to the outbreak of the war they had performed 937 bronchoscopic examinations, on 581 patients, 442 males and 139 females. The findings were negative in 130 cases, or 22.4 per cent. The compilation of full notes on all cases, careful follow-up of the patients and autopsies when possible have proved valuable features of the work.

The bronchoscope used, which is illustrated, was designed by McGibbon. The chief symptoms for which patients have been sent for examination are hemoptysis, dyspnea, pulmonary collapse, suppuration of the lung, pneumonitis and so-called unresolved pneumonia and suspected bronchial neoplasm. The findings have been diverse and often surprising. Of the total 581 patients, 222 presented hemoptysis and a diagnosis of tuberculosis had been made in many of these cases. Simple new-growth was found in 13 of these cases and malignant new-growth in 119.

The therapeutic measures used through the bronchoscope include removal of foreign bodies, drainage of suppurative lesions by suction, lavage of bronchiectatic and abscess cavities, installation of antiseptics, dilatation inflammatory strictures, removal of granulations and simple and malignant tumors, diathermic coagulation of tumors, insertion of tube containing radon seeds and interstitial insertion of radon seeds.

The authors believe that bronchoscopic clinics are necessary but that too many of them should not be established or they will not get the large numbers of patients necessary for the broadest experience. A bronchoscopic team must include a physician, a radiologist, a laryngologist, a thoracic surgeon and trained assistants. —*Audrey G. Morgan.*

DOUGLAS, BRUCE H., and BIRKELO, CARL C. The miniature x-ray film of the chest. *Am. Rev. Tuberc.*, Jan., 1941, *43*, 108–116.

Photoroentgenography is recommended for the study of large groups because it is economical. It is an effective method of case finding without collaborative skin testings. With the use of the 4 × 5 inch film, direct viewings are practical and they have been found to be sufficiently accurate. They are practical by providing a record with one examination—not provided with a procedure such as where the subject may fail to return for checking of the reaction. Standard film studies with or without the use of a Potter-Bucky diaphragm, or laminectomy may be indicated for special cases, the miniature film roentgenography being considered essentially a survey procedure and not a substitute for the finer problems of diagnosis of chest diseases. However, among 6,104 consecutive examinations, large film studies were called for in only about 0.8 per cent.—*A. A. de Lorimier.*

FAULKNER, WILLIAM B., Jr., RODENBAUGH, F. H., and O'NEILL, JOHN R. Influence of the emotions upon esophageal function: A comparison of esophagoscopic and roentgenologic

findings. *Radiology*, Oct., 1941, *37*, 443–447.

Physicians have not been inclined to accept the belief of psychiatrists that emotional disturbance can produce symptoms that cannot be distinguished from those of organic disease. But the authors describe cases in which roentgen examination definitely showed spasm of the esophagus under the influence of unpleasant emotions brought on by suggestions on the part of the physicians themselves, the spasm disappearing completely when happier emotions were restored by the suggestion of pleasant subjects. This possibility of spasm being produced by emotion should be borne in mind in examining the esophagus. An esophagoscopic examination should be made in such cases to be certain of excluding any form of organic disease, such as stricture, ulcer, cancer or other pathological condition.—*Audrey G. Morgan.*

ABDOMEN

Davidson, S. Whately, and Rose, J. Dudfield. The value of co-operation between the radiologist and gastroscopist. *Brit. J. Radiol.*, Oct., 1941, *14*, 307–319.

The authors emphasize the standpoint that gastroscopy and roentgenology should not be considered rival methods but complementary to each other. If roentgen examination were made first, followed by gastroscopy, the necessity for exploratory operation would be greatly decreased. Finer changes in mucosal relief can be detected by gastroscopy than by roentgenology and an accurate knowledge of the condition of the submucosal and muscular layers can also be obtained. The fundus and greater curvature of the stomach can be demonstrated more easily by gastroscopy than by roentgenology, but it is hard to see the cardiac opening, the highest part of the lesser curvature, a small part of the posterior wall, the most medial part of the fundus and the lowest part of the greater curvature by gastroscopy.

During the past two years gastroscopic examinations have been made in 6,000 cases at the [illegible] Victoria Infirmary and roentgen examinations have been made in 256 of these. In 39 cases [illegible] roentgen diagnosis of carcinoma was confirmed by gastroscopic examination, but in 37 it was refuted. If both forms of examination had not been made exploratory laparotomy would have been necessary in the latter cases. In 7 cases in which the roentgen report was negative for cancer it was positive on gastroscopic examination. Thirty-nine cases of ulcer reported by roentgen examination were confirmed gastroscopically, 7 were refuted and 4 with negative roentgen reports were found positive on gastroscopic examination. Two cases of polyps found on roentgen examination were confirmed gastroscopically, but 2 reported negative roentgenologically were positive gastroscopically. In 1 case a roentgen diagnosis of extragastric tumor was changed to one of cancer of the stomach on gastroscopic examination. In only 1 case did gastroscopic examination fail to show a cancer later found on operation. This cancer would probably have been demonstrated by roentgen examination, which was not performed on account of lack of time.

A much more accurate knowledge of the gastric mucosa is being developed by close cooperation between gastroscopist and roentgenologist. —*Audrey G. Morgan.*

Taylor, Hermon. Practical evaluation of gastroscopy. *Lancet*, Feb. 1, 1941, *1*, 131–135.

The flexible gastroscope was first used at the London Hospital in September, 1935. From that time to September, 1939, it was used in 350 cases of dyspepsia. Of these 32 were found to have normal stomachs. In 26 cases (7 per cent) the examination could not be completed, the most frequent cause being inflammatory lesions high up on the lesser curvature. There were local lesions in 112 cases, 34 of these being carcinoma. Small tumors that had not been diagnosed clinically were found in 14 cases and carcinoma was excluded in 68 cases in which it had been suspected clinically. In at least 25 of these cases exploratory laparotomy would have been necessary if gastroscopy had not been carried out.

In a series of 321 cases of carcinoma admitted to the hospital during these years the operability was only 17 per cent in the cases diagnosed without gastroscopy and 68 per cent in those diagnosed by gastroscopy. Both ulcer and cancer can be detected earlier with gastroscopy than without it. The two-view gastroscopic test is valuable. The patient is gastroscoped and an ulcer found. He is put on medical treatment for three weeks and another gastroscopy performed. If there has been healing the ulcer is benign; if there has been no change or progression it is malignant. Among 22 cases in which this test was used 8 ulcers supposed to be benign were found malignant and 14 thought to be malignant were found benign. The so-called thera-

A number of selected cases in which sympathectomy has been performed seem to support this theory. The cases must be selected because if the condition is of very long standing the wall of the intestine can no longer respond to a correction of its innervation. The best way to determine before operation whether it is capable of response is by the use of spinal anesthesia and parasympathetic drugs.—*Audrey G. Morgan.*

WASSON, W. WALTER. Study of the gastro-intestinal tract of children and its relation to the adult. *Radiology*, Sept., 1941, *37*, 277–283.

Some roentgen studies have been made of the gastrointestinal tract of infants and very young children, but not nearly so many as of adults. Very few have been made in the older child and adolescent, probably because there are few diseases at this age.

There are certain differences in the gastrointestinal tract of the infant and adult that seem to be of significance. In the infant the only point of delayed transmission of food is in the stomach, in the adult in the colon. In the adult emptying of the colon may require twenty-four to forty-eight hours longer than in the infant. The mucous membrane of the infant's digestive tract is delicate and the sphincters are not developed as they are in the adult. With advancing age the contractions of the stomach and intestines become stronger and the angulation of the flexures sharper. There is a change of some of the organs from a recumbent to an upright position. Because of the slowing of the progression of the food in the colon and to a lesser degree in the small intestine in the adult, the roentgenogram shows a different pattern. In the infant the upper parts of the small intestine show an irregular globular pattern while in the adult they have a typical snow-flake appearance. The outline of the colon becomes sharper in the adult with more complete filling and more pronounced haustral markings. The appendix of the infant and young child is seldom visible while lack of such visibility in the adult is considered a sign of disease.

The author suggests that systematic studies should be made of the gastrointestinal tract at different ages and that in this way it might be possible to prevent some of the diseases of adult life by correcting functional defects in children. This could be done by studying groups at different ages or by following a single subject through life. The latter method would require that the younger roentgenologists take up the systematic study of the gastrointestinal tract with regard to anatomy and function as well as with regard to disease.—*Audrey G. Morgan.*

RITVO, MAX, and MCDONALD, EUGENE J. Gastrocolic fistula: report of twelve cases. *Radiology*, Sept., 1941, *37*, 269–276.

Gastrocolic fistula is rather uncommon, but it is of great clinical importance because if prompt surgical aid is not given it causes death in a comparatively short time. The most common causes are peptic ulcer, cancer of the stomach and cancer of the colon. Cases caused by cancer have decreased because of better surgical treatment but those caused by peptic and jejunal ulcer have increased because of the increased frequency of posterior gastroenterostomy.

Gastrocolic fistula occasionally begins acutely. Any sudden change in the symptomatology after posterior gastroenterostomy should suggest the possibility of its occurrence. Ordinarily, however, the beginning is gradual and the chief symptoms are loss of weight, nausea, diarrhea, and fecal vomiting. But it is difficult or impossible to make a diagnosis for the clinical symptoms alone. The only means of absolute diagnosis is by the roentgen demonstration of the abnormal opening between the stomach and colon. Sometimes the diagnosis is made by means of a barium meal, sometimes by a barium enema.

The authors discuss 12 cases from the records of the Boston City Hospital. Seven of these followed posterior gastroenterostomy, 3 were caused by carcinoma of the stomach, 1 by cancer of the colon and 1 by a tumor of unknown origin. Eleven of these cases were in men and only 1 in a woman.—*Audrey G. Morgan.*

peutic test for malignancy without gastroscopy is not reliable. Cancer is often accompanied by gastritis and the treatment heals the gastritis but without curing the malignant growth. Gastroscopy will show the malignant lesion in these cases. Patients with dyspepsia should be taught to come for gastroscopic examination.

Gastroscopy is useful in following up ulcer treatment also. Frequently both patient and physician are inclined to give up treatment after a negative roentgenogram but gastroscopy may show persistence of the ulcer.

Normal individuals may have various types of gastric mucosa—average, hyperplastic or hypoplastic. Disease is much more apt to occur in the hyperplastic and hypoplastic types. Acidity is not a reliable indicator of the type or condition of the gastric mucosa. This can be determined only by gastroscopy. A gastric juice with normal or even subnormal acidity may break down a mucosa depressed by chronic inflammation.

Gastroscopy has shown that ulceration occurs after gastroenterostomy if there is excessive hyperplasia of the mucosa. The recurrent ulcer is attributable not to the operation but to the type of mucosa. Therefore gastroscopic examination is of value in determining the cases in which gastroenterostomy should be performed and those in which the operation should be partial gastrectomy. And if gastrectomy is performed it must be extensive enough to prevent recurrent ulceration.

A wider use of gastroscopy would decrease the mortality from cancer of the stomach and the morbidity from gastritis and peptic ulcer. —*Audrey G. Morgan.*

WHITE, J. DUNCAN. An unusual sequel to gastroscopy. *Brit. J. Radiol.*, Nov., 1941, *14*, 364–365.

A case is described in which gastroscopy was performed in a man of fifty-eight because of symtoms of duodenal ulcer and gastritis. The instrument passed without any difficulty, but four days later the patient had fever and dysphagia and roentgen examination showed that the esophagus had perforated and a retropharyngeal abscess had developed. This is unusual when there is no difficulty in the passage of the gastroscope. Probably the instrument caused a slight abrasion of the mucosa which became infected from the esophagus.—*Audrey G. Morgan.*

COLMERS, RUDOLF A. Parasternal diaphragmatic hernia with report of a case on the right side. *Radiology*, Dec., 1941, *37*, 733–739.

A case of right parasternal diaphragmatic hernia is reported in a woman of seventy-seven. Autopsy showed a loop of the transverse colon, part of the great omentum and the upper part of the round ligament of the liver herniated into the right side of the thorax through the foramen of Morgagni. The middle lobe of the right lung was atelectatic and reduced to a thin strip of tissue. It contained a calcified nodule, apparently a healed focus of primary tuberculosis. There was coal pigment in the lung and elastic fibers in the walls of the alveoli. The patient had had no symptoms referable to the hernia until after she was forty years of age.

This case seems to support the theory that these parasternal herniae develop during adult life. The patient had the type of constitution that predisposes to parasternal hernia. The elastic fibers in the walls of the alveoli prove that it developed after birth and the coal pigment in the atelectatic lobe suggests that it appeared during adult life.

Because of the high incidence of strangulation in these cases operation should be performed unless there are strict contraindications. Roentgen examination is useful in diagnosis. If the colon is in the hernia the haustration is often visible. If omentum or gut filled with feces is in the hernia there is a rounded shadow free of the lung and continuous with the diaphragm. Differential diagnosis from tumor may be difficult. In this case, as well as in one described in the literature, the roentgenogram suggested interlobar fluid. The attending physician in that case recommended paracentesis, which if it had been performed would probably have been fatal.—*Audrey G. Morgan.*

DELANO, PERCY J., RONAYNE, FRANK J., and BOLAND, THOMAS B. Rectal dyschezia: a misnomer for megarectum. *Radiology*, Dec., 1941, *37*, 730–732.

A case of enormously dilated rectum filled with masses of feces is described in a woman of twenty-seven. She had suffered from this condition since childhood. It has commonly been called rectal dyschezia and has been attributed to strictures and atresia above the dilated segment. The authors believe, however, that it is caused by anomalies in sympathetic innervation and that the name rectal dyschezia should be given up and that of megarectum substituted.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 JUNE, 1943 No. 6

CONTENTS

Roentgenologic Changes in the Small Intestine in the Presence of the Hookworm . . . . . GEORGE R. KRAUSE, MAJOR, M.C., AND JAMES A. CRILLY, FIRST LIEUTENANT, M.C. 719

Roentgenographic Obstetrical Pelvicephalometry in the Erect Posture . . . . . ROBERT P. BALL, M.D., AND ROSS GOLDEN, M.D. 731

Analysis of Roentgen Pelvimetry by the Johnson Stereoroentgenometer in 379 Cases . . . J. N. ANÉ, M.D., AND LEON J. MENVILLE, M.D. 742

Roentgenologic Localization of the Placenta without Contrast Media . . . . . R. MANGES SMITH, M.D. 750

Syphilitic Spondylitis EUGENE FREEDMAN, M.D., AND I. MESCHAN, M.D. 756

Angiocardiography in Congenital Heart Disease. II. Intracardiac Shunts . . . . . M. F. STEINBERG, M.D., A. GRISHMAN, M.D., AND M. L. SUSSMAN, M.D. 766

Miliary Calcification of the Lung . . . . ERVING F. GEEVER, M.D. 777

Layer Formation in Pyelography . . . . . ALICE ETTINGER 783

Variability in Onset of Ossification in Epiphyses and Short Bones of the Extremities . . . . IDELL PYLE, M.S., AND L. W. SONTAG, M.D. 795

Radiation Treatment of Lymphangioma . . . . . GEORGE W. HOLMES, M.D., AND LLOYD E. HAWES, M.D. 799

New Type of Radium Loading Protective Device . . . . . ANDREW H. DOWDY, M.D., BENJAMIN DUBILIER, M.D., AND DEAN B. COWIE 803

Artificial Decrease of the Radiosensitivity of the Skin and Mucous Membranes in Roentgen Therapy . . . . . DR. PIERRE LEHMANN 811

Cavernous Hemangioma of the Face in an Infant Treated with Radium . . . . . A. W. JACOBS, M.D. 816

Isodose Charts for Fields of Special Usefulness in the Treatment of Cancer of the Uterine Cervix . . . . . SIDNEY M. SILVERSTONE, M.A., M.B., B.CH.(CAMBRIDGE), . . . CARL B. BRAESTRUP, P.E., AND BERNARD S. WOLF, M.D. 819

Editorial

Calcified Pulmonary Lesions 823

Society Proceedings, Correspondence and News Items 826

Department of Technique

An Inexpensive Cassette Changer for Angiocardiography . . . . . EDWARD B. D. NEUHAUSER, M.D., AND CHARLES G. JENNINGS, M.D. 829

Abstracts of Roentgen and Radium Literature 831

Subject Index to Volume 49 839

Author Index to Volume 49 852

GENERAL INFORMATION

Manuscripts offered for publication and other correspondence relating to the editorial management and books for review should be sent to Dr. Lawrence Reynolds, Editor, 110 Professional Building, Detroit, Michigan. Contributions may be sent in foreign languages and will be translated if found acceptable. Original articles are published only with the understanding that they are contributed exclusively to this JOURNAL.

A certain number of illustrations will be supplied free of cost; but special arrangements must be made with the Editor and Publisher for excess illustrations and elaborate tables.

Fifty reprints are furnished without charge to authors. Additional reprints may be purchased according to a scale of prices that accompanies galley proofs.

For information regarding membership in the American Roentgen Ray Society, address the Chairman of the Executive Council, Dr. B. P. Widmann, 250 South 18th St., Philadelphia, Pa.

For information regarding the program of the annual meeting, address the President-Elect, Dr. Sherwood Moore, 510 S. Kingshighway, St. Louis, Missouri.

Correspondence regarding subscriptions, advertisements, and other business relating to THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY should be addressed to Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois. Foreign subscriptions may be addressed to Baillière, Tindall & Cox, 7 and 8, Henrietta Street, Covent Garden, London, W. C. 2, England; H. K. Lewis & Co., Ltd., 136, Gower Street, London, W. C. 1, England; Beutelspacher & Cia., Sarmiento 815, Buenos Aires, Argentina; W. Watson & Sons, Ltd., Watson House, Bligh Street, Sydney, Australia; or to your own agent.

Subscription price a year: $10.00, United States, Mexico, Cuba, Central and South America; $11.00, Canada; $12.00, other countries. Current single numbers, $1.50.

SUGGESTIONS FOR PREPARATION OF MANUSCRIPTS

Manuscripts should be typewritten, with double spacing, and good margins (not on thin paper) and the *original* should be sent to the Editor. The author should keep a carbon copy, as the original is not returned. The name of the author should appear on each sheet of manuscript. Tabular materials should be typed on separate sheets; likewise bibliographical lists, footnotes, etc.

Drawings and charts for reproduction should be made in black (*never* in blue). Photographic prints of plates or slides on glossy paper produce the best half-tones.

All photographs and drawings intended for illustrations should be numbered, the top plainly indicated, and an abbreviated title of the paper placed on the back of *each one*.

Legends for illustrations should be typewritten in a single list, with numbers corresponding to those on the photographs and drawings, instead of attaching each legend to its corresponding figure.

Care in preparation of bibliographies will save much time and correspondence. Each reference in a bibliography should include the following information in the order indicated: Name of the author with initials; title of the article; name of the periodical; year, volume, and pages. It is requested that the authors use the following as a model:

1. Gardner, W. J., and Frazier, C. H. Ventriculography without air injection. J. Am. M. Ass., 1929, 93, 193–194.

The month should be given if the reference is to an issue of the current year. An alphabetical arrangement of authors is preferred.

The author should always place his full address somewhere on his manuscript. This is very important and is often omitted.

The American Journal of Roentgenology and Radium Therapy is owned, maintained by, and in the interests of, the American Roentgen Ray Society, Inc. It is issued monthly by Charles C Thomas, Publisher, 220 East Monroe Street, Springfield, Illinois.

The American Journal of Roentgenology and Radium Therapy does not hold itself responsible for any statements made or opinions expressed by any contributors in any article published in its columns.

Entered as second-class matter February 10, 1930, at the postoffice at Springfield, Illinois, and Menasha, Wisconsin, under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in Paragraph 4, section 538, P.L. and R. authorized February 10, 1930. Delivery to countries in war zones will be attempted, but delivery is not guaranteed, nor is replacement guaranteed, unless request is received within sixty days after the publication of an issue.

CHANGE OF ADDRESS: A 30 day notice of a change of address is requested. When ordering a change of address please give to the publisher both the old and new address.

Copyright 1943 by American Roentgen Ray Society, Inc. All rights reserved. This issue may not be reproduced, in whole or in part, in any form (except by reviewers for the public press) without written permission from the publisher.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 JUNE, 1943 No. 6

ROENTGENOLOGIC CHANGES IN THE SMALL INTESTINE IN THE PRESENCE OF THE HOOKWORM*

By GEORGE R. KRAUSE, *Major, M. C., Army of the United States*
X-Ray Section, Station Hospital
and
JAMES A. CRILLY, *First Lieutenant, M. C., Army of the United States*
X-Ray Section, Station Hospital
FORT JACKSON, SOUTH CAROLINA

INTRODUCTION

ROENTGENOLOGISTS, as a group, paid little attention to the small intestine until the last decade. Diagnosis of disease in this portion of the gastrointestinal tract was almost entirely confined to an occasional case of neoplasm or the presence of ileus. In the past ten years, however, Mackie and his associates,[4,5] Snell and Camp,[8,9] Golden,[1,2] Pendergrass and his coworkers[6,7] and Kantor[3] have contributed much to our knowledge of the abnormal physiology of the small intestine. The list of diseases or clinical entities now known to cause the alterations in the appearance and the function of the small intestine known as the "deficiency pattern", is quite extensive. They are best listed in outline form.

I. Nutritional disturbances
  A. Primary (no obvious anatomic cause)
    1. Celiac disease
    2. Tropical sprue
    3. Non-tropical sprue (idiopathic steatorrhea)
    4. Deficient diet (as pellagra)
  B. Secondary to disease of the gastrointestinal tract
    1. Peptic ulcer
    2. Cancer
    3. Tuberculosis of the small intestine
    4. Biliary or pancreatic disease
    5. Chronic ulcerative colitis
    6. Regional ileitis
    7. Sclerosing inflammation of the mesenteric lymphatics

II. Other causes
  1. Hypoproteinemia (as nephrosis)
  2. Diabetes insipidus
  3. Parathyroid disease
  4. Allergic states

It is not within the scope of this paper to discuss these diseases. It is our purpose at this time to add infestation with the hookworm, *Necator americanus*, to the list of those diseases capable of causing the deficiency pattern.

HOOKWORM INFESTATION

The hookworm is widely distributed throughout the tropical and subtropical re-

* Published with permission of the Surgeon General, War Department, United States Army, who assumes no responsibility for statements made or conclusions reached herein. Presented at the Forty-third Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 15–18, 1942.

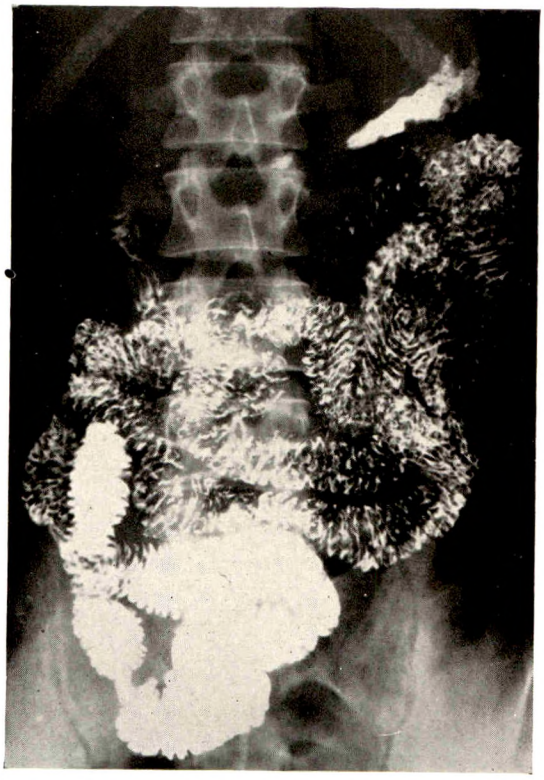


Fig. 1. (J. B.) A normal small intestine one and one-half hours after administration of barium. Note the even caliber of the lumen of the intestine, the continuous column of barium and the delicate, sharply defined mucosal folds. Contrast this appearance with that of the succeeding roentgenograms.

gions of the world, but *Necator americanus* is the only hookworm of importance to man in the Western Hemisphere. This parasite is found in the southern half of the United States, the Caribbean Islands, Central America and the northern portion of South America. It must be remembered that persons who have lived and travelled in these portions of the world may acquire and harbor these parasites when they return to more temperate climates.

Necator americanus, in its adult phase, inhabits the small intestine, especially the middle third, and is responsible for the syndrome of hookworm disease. The males measure 7–9 mm. in length by 0.3 mm. in diameter; the females are slightly larger. The details of the life cycle and the morphology have been clearly worked out and are described in the literature on parasitology.

Hookworm infestation usually begins in childhood when exposure is frequent, since in the regions mentioned children usually go barefoot, both by preference and for reasons of economy. The worms are known to persist in the small intestine for at least six to seven years following the last infestation, but probably remain for longer periods.

The typical patient suffering from hookworm disease is chronically tired, feels "below par" and complains of lassitude. Heartburn, flatulence, epigastric fullness and pain are relatively frequent. The patient is usually thin and has a sallow complexion. Laboratory studies often reveal a secondary hypochromic anemia (due to chronic blood loss) and an eosinophilia.

In severe cases these symptoms are more pronounced. The lassitude becomes apathy, the gastrointestinal symptoms become more severe and the anemia quite pronounced.

TECHNIQUE OF EXAMINATION

Four ounces of barium sulfate suspended in 5 ounces of normal saline were administered in the morning to the fasting patient. The usual roentgenoscopic examination of the stomach and duodenal bulb was made. The patient was examined at intervals of one-half hour either roentgenoscopically or roentgenographically, until the head of the barium column reached the cecum and the remainder of the barium was in the ileum. At this time, usually three to four hours after the start of the examination, the patient was given a glass of milk and a slice of bread and butter (to test the food reflex). A roentgenogram was then made in one-half hour and thereafter as indicated until the barium cleared the small intestine. The examination was discontinued at nine hours even if an ileal residue was present.

SELECTION OF CASES

Complete small intestinal studies were made on 97 young white soldiers (eighteen to thirty-four years of age) in whose stools the ova of *Necator americanus* were present.

In almost all instances the ova were detected in two or more stool specimens. None of these men had any systemic disease known to cause alterations in the small intestinal pattern; none had a remote or recent history of inadequate diet or chronic alcoholism; none had demonstrable organic disease of the gastrointestinal tract. Two men were Puerto Ricans, all the rest had been born and reared in southern states with two exceptions.

On the basis of the clinical findings alone, these cases were divided into two groups, clinically significant "hookworm disease," and incidental, asymptomatic "hookworm infestation."

A man who passed the ova of *Necator americanus* in his stool was classed as suffering from clinically significant "hookworm disease" only if he entered the hospital with the typical clinical syndrome, with anemia or with chronic complaints referable to the gastrointestinal tract, and provided that he suffered from no other demonstrable disease, systemic or gastrointestinal. There were 44 such cases.

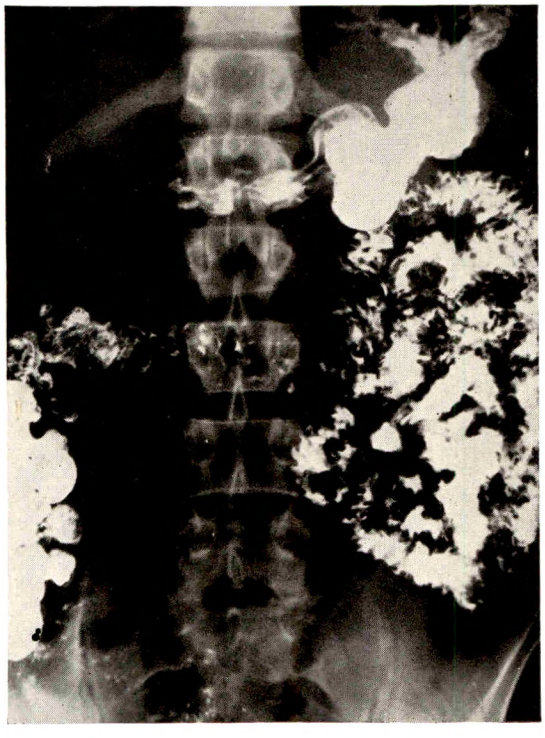


FIG. 2. (L. W.) Dietary deficiency due to limited diet before and after operation for perforated gastric ulcer. This roentgenogram made immediately after roentgenoscopy of the stomach and duodenum shows a moderately severe distortion of the jejunal pattern. There is coarsening of the mucosal folds and some segmentation. Barium administered six hours earlier is in the cecum and ascending colon. The jejunal changes were found incidentally on a gastrointestinal series (see Fig. 3).

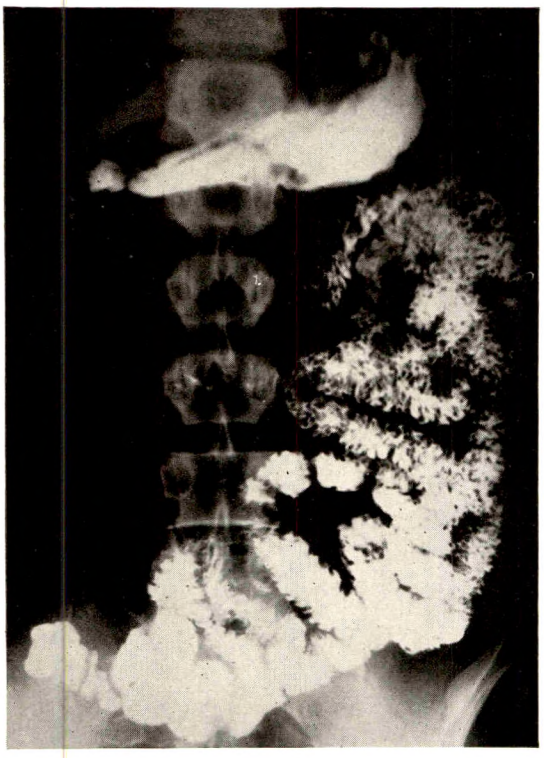


FIG. 3. (L. W.) Same case as Figure 2. After administration of liver extract twice weekly for five weeks this roentgenogram, made at one-half hour, shows the mucosal pattern to be almost normal, and the segmentation to be absent. This case is presented to illustrate the type of findings described in the literature as the "deficiency pattern." Note the similarity of these changes to those seen in the succeeding reproductions, which, however, are due to the hookworm.

Any patient in whose stool ova were found on a routine examination, who had no gastrointestinal symptoms, no anemia, no loss of "pep" and no lassitude was regarded as a case of incidental, asymptomatic "hookworm infestation," of no clinical significance. There were 53 such cases.

It should be especially noted that this classification was made entirely on clinical

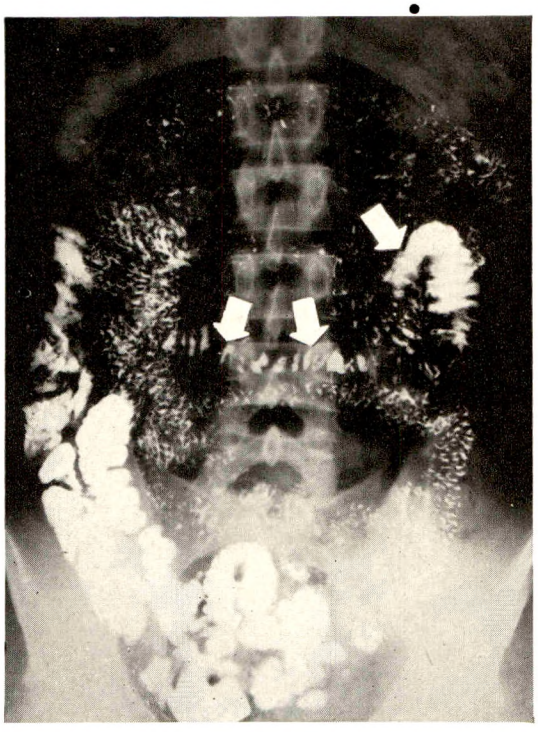


Fig. 4. (L. P.) "Hookworm disease." At one and one-half hours a single loop of jejunum exhibits coarsening of the mucosal folds with one area of segmentation (arrows). The jejunum is otherwise normal. The barium column has reached the hepatic flexure, indicating hypermotility. Minimal changes. (See Fig. 5.)

grounds, and that the roentgenograms were examined objectively for the presence of variations from the normal pattern.

ROENTGEN MANIFESTATIONS

The abnormalities of the physiology of the small intestine known as the "deficiency pattern" are manifested by variations from the normal in the appearance and function of the mucous membrane (including the muscularis mucosa) and the tunica muscularis propria (or true muscle coat).

These may be outlined as follows:

I. Abnormal function of the mucous membrane
   - A. Pattern changes of the mucosa (in increasing severity)
     1. Coarsening of folds
     2. Irregularities of folds
     3. Flocculation
     4. Obliteration of folds

II. Abnormal function of tunica muscularis
   - A. Motility
     1. Hypermotility
     2. Hypomotility
   - B. Tonicity
     1. Hypertonicity
        - a. Segmentation
     2. Hypotonicity
        - a. Dilatation

These same alterations have been encountered in this study. It is evident that a uniform type of response occurs in the small intestine as the result of a number of different influences.

Coarsening of the mucosal folds in the mid and distal jejunum was the earliest var-

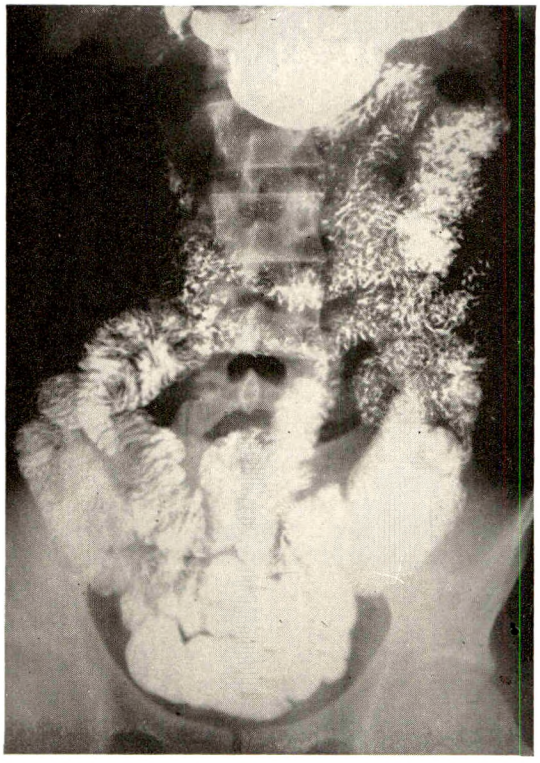


Fig. 5. (L. P.) Same case as Figure 4. Ten weeks after successful anthelmintic therapy this roentgenogram was made at one hour after the administration of barium. There is still slight hypermotility, but the barium column is continuous and the mucosal folds are normal. There is practically a complete return to the normal appearance. The patient is clinically well.

iation from the normal found in the mucosa. The hookworm itself is too small to demonstrate roentgenographically. In the more advanced cases, irregularities of the mucosa were present and finally the mucosa was entirely obliterated in a few severe cases. Flocculation was seen in a number of cases, but always in moderately and severely altered small intestines.

Alterations in the muscular function were frequently noted. Hypermotility (barium reaching the cecum in one hour or less) and localized areas of segmentation were common features, but hypomotility and dilatation (loss of tone) were characteristically seen only in far advanced cases. All of these changes are clearly illustrated in one or more of the roentgenograms reproduced herewith. The legends are self explanatory.

In some cases the mucosal changes were visible first, and in others, segmentation or hypermotility (muscular functions) were the first abnormal findings. In well marked cases both mucosal and muscular changes were always present, although in any given case either might predominate.

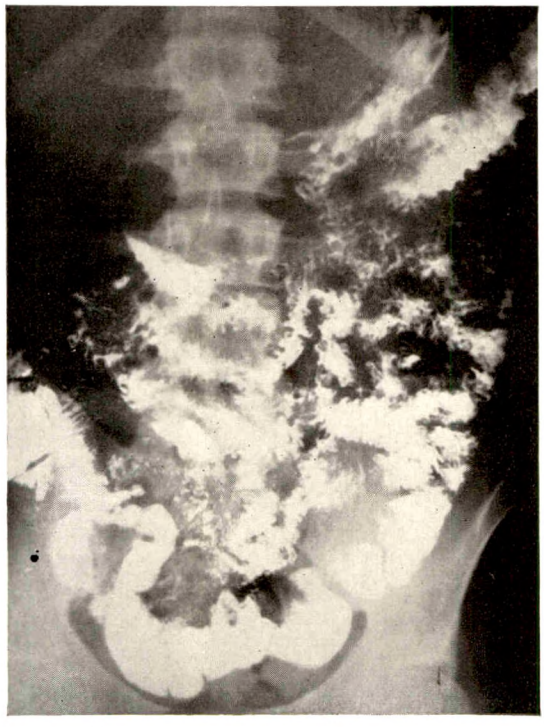


Fig. 6. (C. T.) "Hookworm disease." Roentgenogram made at one hour reveals definite hypermotility with break up of the barium column. There is dilatation of a loop of proximal jejunum, coarsening of the mucosal folds and moderately severe segmentation. Moderately severe changes. (See Fig. 7.)



Fig. 7. (C. T.) Same case as Figure 6. Twenty weeks after successful anthelmintic therapy this roentgenogram made at one and one-half hours shows that the hypermotility and segmentation are no longer present. The mucosal pattern still shows some abnormality. The patient was clinically cured.

In almost every case an adequate food reflex was present. In the few cases in which the reflex was absent or diminished there was no relation to the presence or absence of other abnormal roentgen manifestations.

The mucosal folds in the ileum are normally quite low, and therefore alterations in the mucosal pattern were not as clear cut as in the jejunum. Furthermore, segmentation and stasis occurred in the distal half of the ileum when the rest of the small intestine was quite normal, and when the patients had no symptoms. It appears that

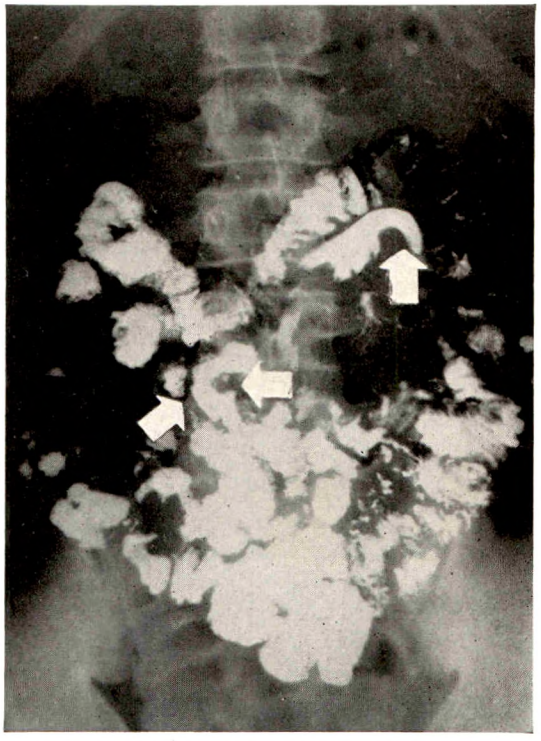


Fig. 8. (A. D.) "Hookworm disease." This roentgenogram at one and one-half hours presents severe distortion of the normal pattern in the jejunum. There is marked segmentation (arrows), break up of the barium column and coarsening of the mucosal pattern, which in some areas is obliterated. Severe changes. (See Fig. 9.)

changes in the ileum are not as well defined as those in the jejunum, and therefore not valuable as a diagnostic guide.

An occasional patient was encountered whose small intestine appeared to be normal at the start of the examination and then abruptly presented marked changes from the normal in succeeding roentgenograms. Conversely, an occasional small intestine was seen which appeared to be abnormal at the start, but which after one or two hours assumed a normal pattern. These findings were confirmed on re-examination. The significance of these alterations is not clear. Food allergy was excluded by the fact that these changes occurred before the test meal was given.

Each small intestine study was graded and placed into one of four groups on the basis of the presence or the severity of these abnormal findings. These groups were entitled normal small intestine, and minimal, moderate and severe alterations from the normal.

In the 44 cases of "hookworm disease" the following distribution occurred:

Normal small intestine	4
Minimal alterations	14
Moderately severe alterations	11
Severe alterations	15

In the 53 cases of "hookworm infestation" the following distribution occurred:

Normal small intestine	33
Minimal alterations	16
Moderately severe alterations	2
Severe alterations	2

These tables show that 40 of 44 cases of clinically significant "hookworm disease"



Fig. 9. (A. D.) Same case as Figure 8. Ten weeks after anthelmintic therapy this roentgenogram taken at one and one-half hours shows remarkable improvement but not complete return to normal. There is still present a large dilated loop of jejunum which has coarsened folds (arrows), but the remainder of the mucosal folds are almost normal and the barium column is more nearly continuous. The patient was clinically cured.

in this study showed pathologic changes in the small intestine. Of the cases without symptoms, i.e. the incidental cases of "hookworm infestation" only 4 of 53 cases showed more than minimal changes.

It has long been established that the severity of the infestation with the hookworm roughly parallels the severity of the symptoms. A significant correlation therefore exists between the presence and the extent of the physiologic alterations seen on the roentgenograms, the clinical findings and the severity of the hookworm disease. This close relationship further indicates that the hookworm is the sole cause of the alterations from the normal pattern encountered in this study.

It should be noted at this point that the 2 cases which were entirely asymptomatic, but which showed severely damaged small intestines, both gave a history of having been treated for hookworm in childhood, and of having had the ground itch on numerous occasions. Therefore, in these instances it is probable that the pathologic manifestations now visible were due to an infestation of considerable severity in the past which caused irreparable damage to the small intestine. This is further supported by the fact that re-examination following successful anthelmintic therapy showed no change from the appearance seen on the original examination.

The 4 patients with "hookworm disease" whose small intestines were normal by roentgen examination were borderline cases, i.e. the symptoms were mild and vague. It is probable that they should have been classed as incidental cases but at the time of the original interview they were regarded as significant, and we have not changed the grouping.

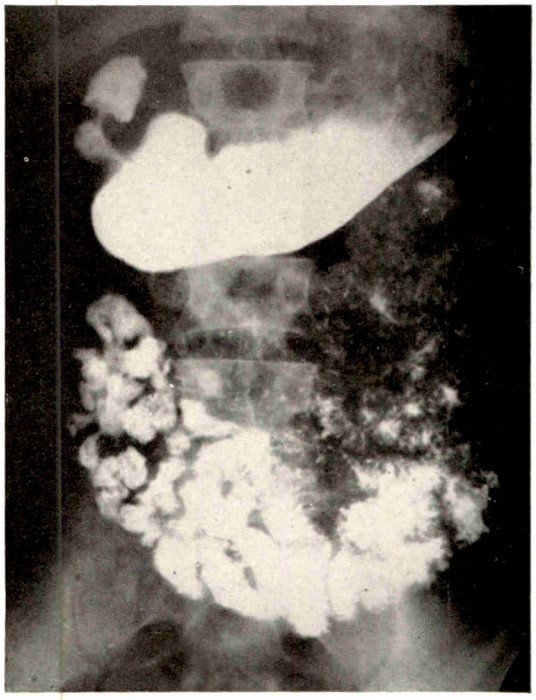


FIG. 11. (M. W.) "Hookworm disease." Roentgenogram made at one-half hour demonstrates complete obliteration of the mucosa and severe segmentation. This patient was critically ill, with a red blood cell count of 1,000,000, and required two transfusions before this study was made.

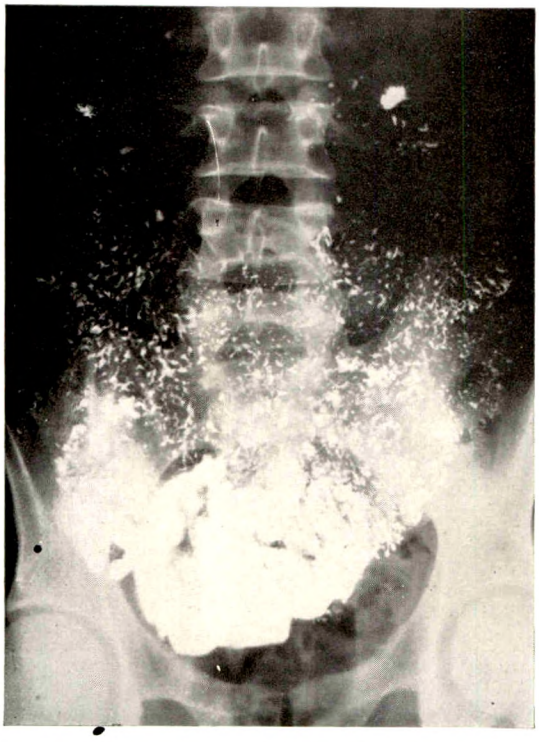


FIG. 10. (J. S.) "Hookworm disease." Roentgenogram made at three and one-half hours shows that no barium has reached the cecum. The barium is clumped in the ileum, but throughout the jejunum there is definite and well marked flocculation, indicating a disturbance of the mucosal pattern.

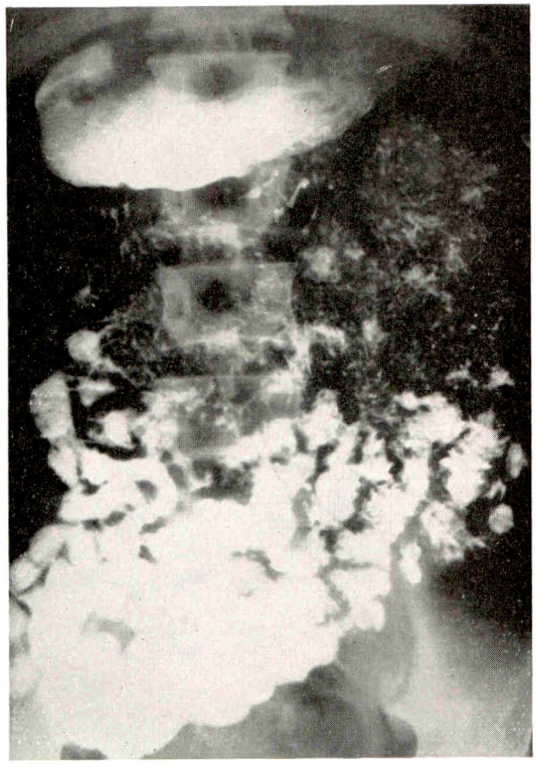


Fig. 12. (M. W.) Same case as Figure 11, same day. This roentgenogram was made at two hours. There is demonstrated a delayed gastric emptying time and hypomotility in the small intestine. The segmentation is pronounced. The jejunal mucosa has a "washed out" appearance. This is a very severe disturbance. (See Fig. 13.)

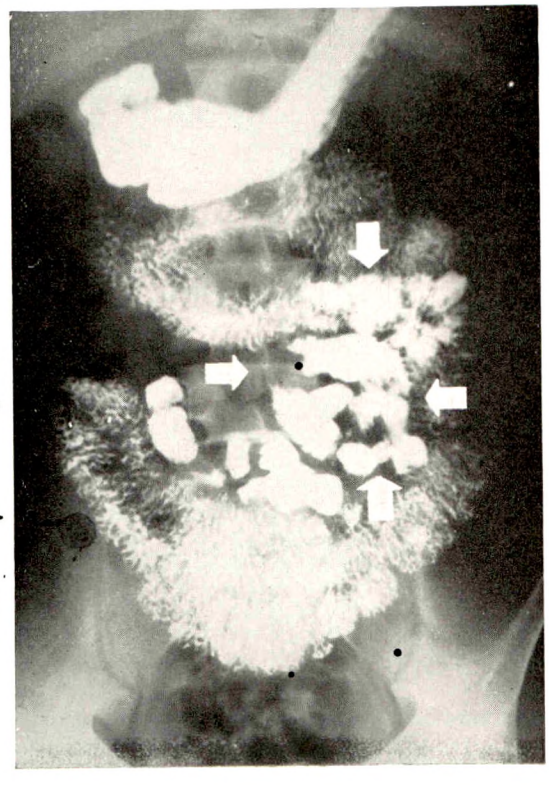


Fig. 13. (M. W.) Same case as Figure 12. Four weeks after successful anthelmintic therapy this roentgenogram, made almost immediately after the administration of the barium, shows a single group of severely distorted jejunal loops (arrows), in which segmentation and loss of mucosal folds is prominent. The remainder of the small intestine visible is practically normal. The red blood count was 3,500,000.

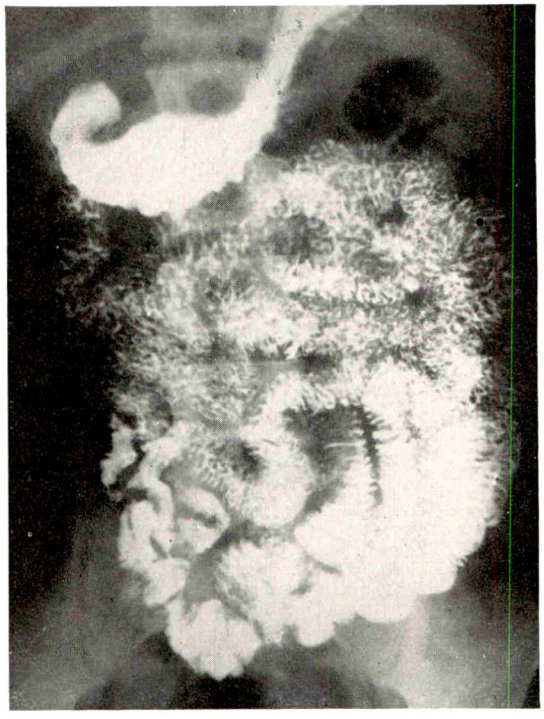


Fig. 14. (M. W.) Same case as Figure 13. Six weeks later (ten weeks after the first examination) this roentgenogram made at one-half hour shows an almost complete return to normal. There is still some coarsening of the mucosa. The red blood count was 3,900,000 at this time and the patient was clinically well.

Twenty-nine cases with abnormal small intestines were re-examined after successful anthelmintic therapy at intervals varying from five weeks to six months. Eighteen

of these patients had had minimal alterations, of whom 5 were normal and 5 showed improvement when re-examined. Eight showed no change, in spite of clinical cures.

Eleven of the patients re-examined had originally been found to have moderately or severely damaged small intestines. None of these returned to normal after therapy. Eight showed improvement and 3 showed no change. The tendency for return to normal was most marked in the type of change which predominated in the individual case. That is, if mucosal changes predominated, the return to normal was most marked in the mucosal pattern. The same held true if changes in the tunica muscularis were predominant.

The experience of others (Snell and Camp, Golden) with other causes of the deficiency pattern is thus confirmed. Severely distorted small intestines may return towards, but not to, the normal. Some cases with only minimal changes may exhibit *restitutio ad integrum*. The clinical improvement was more rapid and more marked than the roentgenologic improvement.

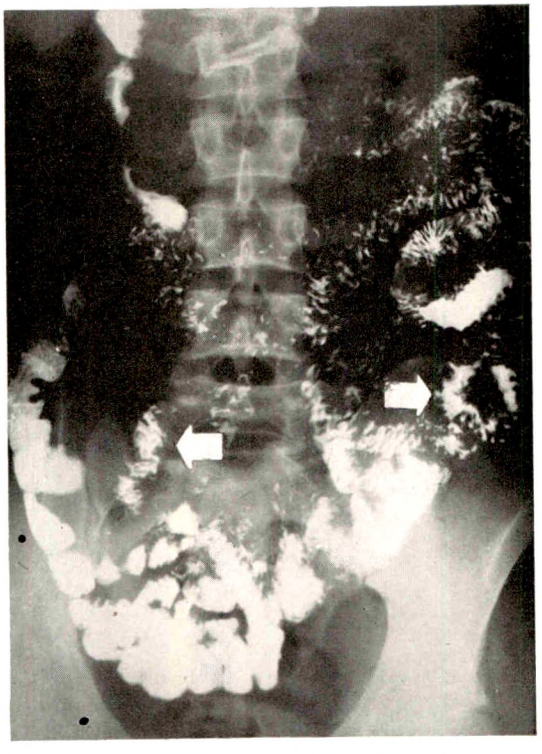


Fig. 15. (E. E.) "Hookworm disease." Roentgenogram made at one and one-half hours shows some break up in the barium column with segmentation (arrows) and hypermotility. The mucosal pattern is relatively normal.



Fig. 16. (E. E.) Same case as Figure 15. Nine weeks after successful anthelmintic therapy and a remarkable clinical recovery, there is practically no improvement in this one and one-half hour roentgenogram. This patient had had the ground itch on many occasions as a child, and it is possible that the changes seen represent the end stage of a remote infestation.

MECHANISM

Golden discussed the possible physiologic mechanisms involved in the production of the "deficiency pattern." He pointed out that the diversity of causes suggested that some common mechanism must be involved, and that, inasmuch as the intramural nervous systems controls, or at least influences, the intestinal movements, it might well be the common factor. The similarity of the changes in the small intestine which we have encountered in this study to those

of the deficiency pattern indicates that in this instance also some systemic mechanism is called into play.

The actual physical presence of the hookworm in the lumen of the small intestine is probably not the determining factor, since no other reported cause of the deficiency pattern possesses this factor. Furthermore we have observed similar changes in 2 cases of *Trichuris trichiura* and 1 each of *Hymenolepis nana* and *Ascaris* infection.

Anemia is probably not the cause, since very few patients had severe anemia, and there was no constant correlation between the degree of anemia and the extent of the changes in the small intestine. Hypoproteinemia (as a result of chronic blood loss) could not be excluded since we were unable to have quantitative protein determinations done, but no patient had edema.

The possibility of an exotoxin must be considered but no evidence has been produced to date to indicate that the hookworm produces such an exotoxin.

It is probable that the absorption of certain essential dietary factors is interfered with as a result of the damage done to the small intestine by the hookworm. It would have been of considerable interest to administer liver extract parenterally before beginning anthelmintic therapy. A return to the normal pattern under such parenteral therapy would have definitely established the evidence of a deficiency, due to the hookworm, as the cause of the abnormal small intestinal pattern. Unfortunately this could not be done. Considerable pressure existed to return these men to duty as soon as possible, and a delay of some weeks before beginning anthelmintic therapy could not be allowed. It is hoped that at some time in the future this aspect of the problem can be investigated.

SUMMARY AND CONCLUSIONS

1. Certain alterations in the small intestinal pattern have been described in a number of clinical entities under the term "deficiency pattern." This report indicates that infestation with the hookworm, *Necator americanus*, causes this same alteration in the physiology of the small intestine. Therefore, when the deficiency pattern is seen, the patient's stools should always be examined for the ova of intestinal parasites.

2. Complete small intestinal studies were made on 97 young adult, white males known to harbor the *Necator americanus*, and who had no other disease known to cause the deficiency pattern. Of the 44 cases of clinically significant "hookworm disease," 40 showed abnormalities of the small intestinal pattern, 26 of which were moderately or far advanced. Of the 53 cases of asymptomatic incidental "hookworm infestation," 33 had a normal small intestine, 16 showed minimal variations from the normal and only 4 had severe alterations of the normal pattern.

3. After anthelmintic therapy alone, there was a return towards, but not to, the normal pattern, in severe cases. Minimal alterations disappeared entirely in some instances.

4. A significant correlation exists between the presence and extent of the physiologic alterations seen on the roentgenograms, the clinical findings and the severity of the infestation with the hookworm.

5. The pathogenesis of these changes is still obscure.*

REFERENCES

1. GOLDEN, R. The small intestine and diarrhea. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 892–901.

2. GOLDEN, R. Abnormalities of the small intestine in nutritional disturbances; some observations on their physiologic basis. Carman Lecture. *Radiology*, 1941, *36*, 262–286.

* Since this article was written a report by A. McKenzie (Deficiency of vitamin B_1 in hookworm anaemia, *Lancet*, 1939, *1*, 1143–1145) has come to our attention. In treatment of the anemia of hookworm disease McKenzie found that simple iron preparations were the most efficacious, but that the edema present in his severe cases yielded only to large doses of vitamin B_1 given parenterally. A generous diet had not proved curative, and brewers' yeast had yielded only slight improvement, indicating that impaired absorption was the most probable explanation. This treatment was carried out before anthelmintic therapy.

The patients had been on the standard diet supplied estate workers in East Africa. Other workers not infested with the hookworm showed no such deficiency.

This report of improvement of clinical symptoms confirms our opinion that the changes visible roentgenologically are actually, in large part, a "deficiency pattern."

would add 6 mm. to the diameter of the bony cranium as obtained from the mean corrected measurements of the film images. Since the ratio of the diameter to the circumference of a circle is pi, 3.1416×0.6 cm. gives the difference between the circumference of the bony cranium and that of the surface of the scalp; therefore, the scalp volume is included in the estimate of the fetal cranium by adding 2 cm. to the mean circumference measurements of the skull. Figure 6 is a chart showing the volume of the sphere from circumference measurements.

It should be emphasized that the mean (average) measurement of the fetal cranium is made from the corrected measurements since the object-diaphragm surface distances may be different in the two views. Parenthetically, it may be added that one should not forget to add 2 cm. to the mean measurement to include the scalp.

FETAL CRANIAL MEASUREMENTS IN BREECH PRESENTATIONS

In a breech presentation the fetal cranial image is not close enough to the pelvic inlet to make an accurate comparison of size. However, the circumference of the fetal cranium can be measured in right angle views and the mean measurement, plus 2 cm. for scalp allowance, can be compared with the volume capacity of pelvic diameters. The cranial measurements are made from roentgenograms taken with the central ray passing through the body of the mother at or near the level of the fetal head as described under technique. The measurements and computation are the same as described for a cephalic presentation except that the object-diaphragm surface distances are obtained from different points. The only difference is that the line is extended up from the sacrum in the lateral view to obtain the object-diaphragm surface distance for the image measured in the anteroposterior view. Similarly the line is extended up from the inner border of the greater trochanter in the anteroposterior view to obtain the object-diaphragm surface distance of the image measured in the lateral view. The standing position of the patient eliminates shifts of the fetus between exposures except for the rare instance of an active fetal movement.

DISCUSSION

The erect posture is preferable to any other position for a roentgenographic examination of the obstetrical patient. Because of the effect of gravity, the fetal head will usually be found dipping into the pelvis and thereby permit a good visual estimation of the spatial relationship between the fetal head and bony pelvis. In cases of cephalic presentation, the normal position of the head in the midcoronal and median planes permits the recognition of soft tissue dystocia or placenta praevia when found displaced from the normal position. Roentgenograms taken with the patient erect are more satisfactory for mensuration than when taken in any other position. The erect posture is more pleasant and more comfortable to the patient near term.

The measurements described above are useful (1) for the purpose of clinical obstetrics, to aid in determining possible difficulty in delivery, and (2) for the purpose of anthropological study and statistical analysis.

For clinical purposes some of the diameters mentioned above are of no immediate significance. It has become our custom in writing reports to give the following diameters: anteroposterior (*B*) and transverse of the inlet (*L*), interspinous (*K*), intertuberous (*N*), base of the subpubic arch (*T*), sagittal diameter of the fore pelvis (*D*), and of the posterior pelvis (*E*). Obviously from the obstetrical standpoint, the three most important diameters are the anteroposterior and transverse of the inlet and the interspinous. The report includes a description of the shape of the inlet, using the terms recommended by Caldwell and Moloy, of the shape of the sacrum, of the type of sacrosciatic notches (male or female) and whether wide or narrow, of the side walls of the pelvis, i.e.,

face distance of the biischial spine diameter (Fig. 4, *K*), the distance from the biischial spines to *tt* in Figure 3 is measured. The total object-film distance will of course be this measurement plus the diaphragm surface-film distance. The corrected dimension of the biischial spine diameter is then obtained by use of the nomogram. A graphic summary of the points used to obtain the object-diaphragm surface distances of the

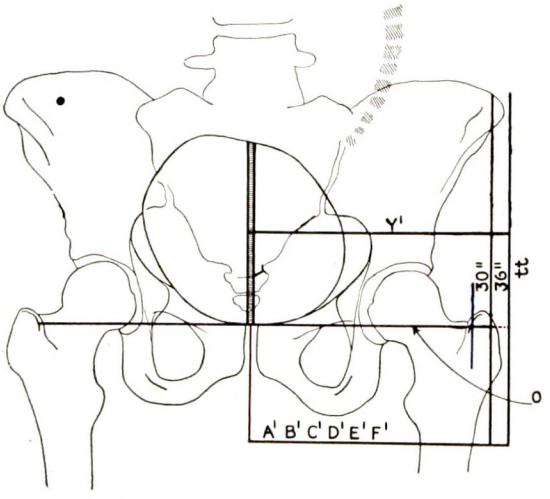


Fig. 8. Tracing of roentgenogram shown in Figure 4. The prime letters indicate the object-table top distance of the dimensions shown in Figure 3. See text for description of method of measurement.

transverse pelvic dimensions is shown in Figure 7. Similarly the points of measurement for object-diaphragm surface distances of the dimensions in the median plane of the pelvis are shown in Figure 8.

The points of measurement of the greatest transverse diameter of the pelvic inlet should be explained in detail. In the anteroposterior view, it will obviously be the greatest horizontal diameter of the inlet (Fig. 4, *L*). In order to locate this point in the lateral view, to obtain its distance from the diaphragm surface, a line is drawn parallel to *C* (Fig. 3) passing through the ischial spines. This line is labelled *cc* in Figure 7. The point of intersection of *cc* with the iliopectineal line is the point of the greatest transverse diameter of the inlet regardless of the shape of the pelvis. We have examined a large series of articulated pelves and checked this observation in stereoscopic views. The greatest variation has not been over 0.5 cm. in any pelvis examined.

The usual reference to the size of the fetal head, in American literature, is in terms of cardinal diameters such as the suboccipitobregmatic, occipitofrontal, bitemporal, biparietal, etc. For purposes of roentgenographic mensuration it is believed that a more accurate estimate of the total size of the fetal cranium can be made from circumference measurements of the fetal cranial image. A diameter measurement may be foreshortened when lying in an oblique position in reference to the central ray. Furthermore, it is not always easy definitely to locate end points, even in stereoscopic views. When the mean circumference measurement of the fetal cranial image is made from right angle views (anteroposterior and lateral), the total volume of the cranium can be calculated. The perimeter of the cranial image is easily located and can be traced and measured in centimeters with a map measure.

In order to correct for the magnification of the fetal skull image perimeter measurement, the object-diaphragm surface distance is obtained from the roentgenogram taken at right angles. The image in the anteroposterior view (Fig. 4, *X*) is equivalent to a cross section taken in a vertical plane represented by a heavy striated line in Figure 7. The object-diaphragm surface distance is represented by *X'* in Figure 7. Thus, the circumference measurement is corrected in a manner similar to that used in correcting the pelvic dimensions as obtained from the roentgenographic image. The object-diaphragm surface distance for the cranial image in the lateral view is shown in Figure 8, *y'*.

The volume of the scalp of the fetus near term is about one-fifth the total volume of the cranium. Allowance should be made for this in estimating the total volume of the fetal cranium. The average thickness of the scalp of the newborn is about 3 mm. This

At 30 inch anode-film distance, 2 cm. should be added to the measurement of *O* obtained from the anteroposterior view. One-half of the resulting figure gives approximately the distance of the median sagittal plane of the pelvis from the diaphragm surface. The figures obtained in this way may be a little larger or a little smaller than those obtained with the technique rule as described above, but the variation in the results of the two methods is usually under 0.5 cm. and is rarely over 1.0 cm., which produces a negligible difference in the corrected pelvic measurement. For example, a 2 cm. difference in the determination of the intertrochanteric distance makes a change of 1 cm. in the distance of the median plane of the pelvis from the film which, in turn, produces only about 1 mm. difference in the corrected measurements of the diameters in the sagittal plane of the pelvis, which is obviously unimportant. The reason for this difference in the results of the two methods probably lies in the different amounts of adipose tissue lying lateral to the greater trochanter in different individuals.

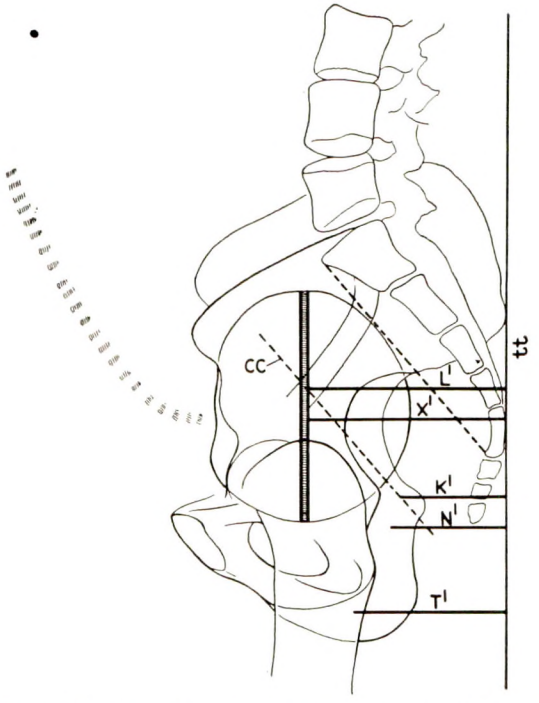


FIG. 7. Tracing of roentgenogram shown in Figure 3. The letters marked prime indicate the object-table top distances of the transverse dimensions shown in Figure 4 used in correcting the measurements. In this instance, the distance from the table top (*tt*) of the greatest transverse diameter of the inlet (*L'*) happens to be practically the same as that (*X'*) of the central vertical transverse plane of the fetal head in the anteroposterior view.

One-half of the bitrochanteric diameter, as previously stated, is the object-diaphragm surface distance. The distance from the diaphragm surface to the film is a constant which varies only with the particular Potter-Bucky diaphragm and make of the apparatus. The diaphragm surface-film distance plus the object-diaphragm surface distance is, of course, the object-film distance. The correction of the measurements of the dimensions shown in Figure 3 is then made by placing the movable arm of the nomogram over the appropriate points on the two scales to left, shown in Figure 5, tightening the knurled knob over the slot and then swinging the movable arm around to where it intersects the scale of measured dimension. The corrected dimension is read from the point of intersection of the hair line in the movable arm on the scale of true dimension.

The pelvic dimensions shown on the anteroposterior view (Fig. 4) may be defined as follows:

M. Greatest width of the sacrum.
L. Greatest transverse diameter of the pelvic inlet.
K. Biischial spine or interspinous diameter.
O. Inner bitrochanteric diameter.
N. Biischial diameter taken at level of inferior borders of ischial spines.
T. Biischial diameter taken at lowermost point of ischial tuberosities (base of subpubic arch).

The object-diaphragm surface distances of these pelvic dimensions may be very closely estimated from the lateral roentgenogram. A line, *tt*—Fig. 3, is drawn parallel to the film border and passing through the most posterior prominence of the sacrum. This line may represent the diaphragm surface. To obtain the object-diaphragm sur-

a transparent arm containing a hair line to be pivoted at the proper point for correcting the magnification on the film image. The movable arm is first placed on the points of the scales showing object-film distance and anode-film distance. A knurled knob over the pivot point is tightened and the arm is then swung over the scale marked "measured dimension." The corrected (true) dimension is then read from the point of intersection of the hair line in the movable arm with the scale marked "true dimension." By the use of the nomogram, the correction of film-image magnifications can be done rapidly and without any mathematical computation. A chart (Fig. 6) on the board gives the volume of a sphere of known circumference or diameter so that the fetal head may be compared with pelvic diameters in terms of volume and volume capacity respectively.

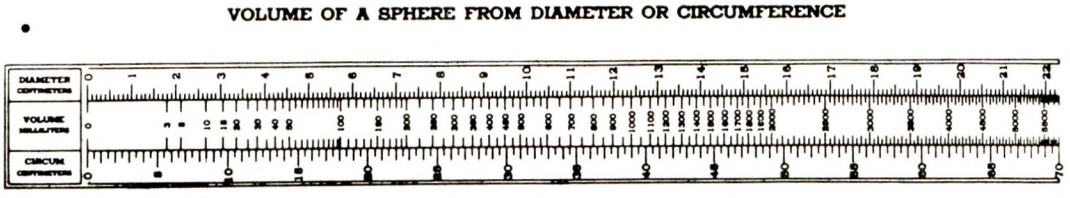


Fig. 6. A chart showing the volume of a sphere from either a circumference or diameter measurement. It is convenient for translating a measurement of a sphere into units of volume.

The pelvic dimensions (diameters) shown in Figure 3 may be defined as follows:

A. Symphysis pubis to tip of sacrum.
B. Symphysis pubis to sacral promontory.
C. Sacral promontory to sacral tip. Vertical height of sacrum.
D. Median anteroposterior diameter of the fore pelvis. Symphysis pubis to median plane of biischial spine diameter.
E. Median anteroposterior diameter of the posterior pelvis. Sacral tip to median plane of biischial spine diameter.
F. Symphysis pubis to third sacral segment.
H. Sacral promontory to median plane of biischial tuberosities.
Vertical height of pelvis.
P. Symphysis pubis to median plane of biischial tuberosities.
Q. Sacral tip to median plane of biischial tuberosities.

All of these pelvic dimensions are in the median plane of the pelvis and consequently are located equal distances from the anode and film when the roentgenogram is exposed. In other words, the magnification factor is the same for all these dimensions. To correct magnification, it is necessary to know the object-film distance (the pelvic dimension is the object) and the anode-film distance. It is easy enough to select a convenient anode-film distance. In our experience a 36 inch anode-film distance has been found to be very satisfactory. The object-film distance will be the distance from the median plane of the pelvis to the film. Obviously this could be easily measured on the patient by taking one-half the bitrochanteric diameter and adding it to the distance from the surface of the Potter-Bucky diaphragm to the film. Since it is not always convenient for the roentgenologist to make the bitrochanteric diameter measurement on the patient, the technician can take this measurement with the technique rule when the patient is posed for the lateral view, or can measure the distance from the center of the sacrum (the line of the spines of the sacral segments) to the diaphragm surface.

The distance of the median plane of the pelvis from the surface of the erect Potter-Bucky diaphragm (hereinafter called the "diaphragm surface") when the lateral view is exposed, can be estimated also from the anteroposterior view. In Figure 4, *O* is the distance from the inner border of one greater trochanter to the other. With a 36 inch anode-film distance, 4 cm. should be added to the dimension *O* to obtain the approximate bitrochanteric diameter of the patient.

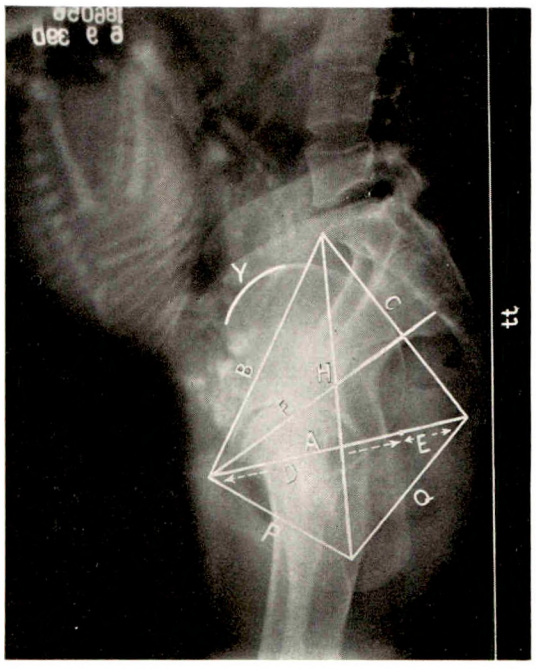


FIG. 3. Lateral roentgenogram of the pelvis taken with the obstetrical patient standing erect. The fetal head passes far down into the pelvis to the level of the ischial spines, showing at a glance that engagement occurs without difficulty. The lettered internal pelvic dimensions are measured and their magnification corrected (see text) to obtain the spatial relationship between the fetal head and pelvis. All of the dimensions shown are in the median plane of the pelvis. *tt* is a line parallel to the film border passing through the most prominent posterior border of the sacrum and may be used to represent the Potter-Bucky diaphragm surface for obtaining the object-film distance which is necessary for correction of the transverse diameters shown in Figure 4 (see Fig. 7 and text). Not all of the dimensions indicated here are necessary for clinical pelvimetry at the present time. The report routinely includes *B* (anteroposterior diameter at the inlet), *D* (the median anteroposterior diameter of the fore pelvis, i.e., the distance from the plane of the ischial spines to the symphysis pubis), and *E* (the same diameter of the posterior pelvis, i.e., from the plane of the ischial spines to the sacral tip). The other dimensions are useful for anthropological study and statistical analysis.

gram,[7] used by the authors, has proved to be satisfactory for this purpose. It has four plotted scales and a central transfer axis (Fig. 5). The scales are printed on a rigid board, while the transfer axis is replaced by a slot in the board. This permits

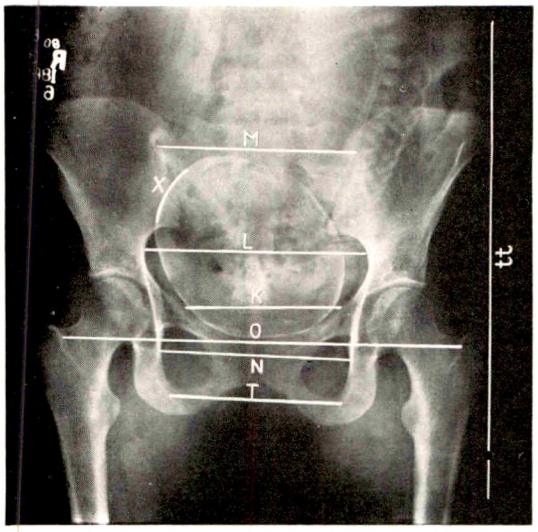


FIG. 4. Anteroposterior roentgenogram of the obstetrical patient taken standing. The fetal head lies in the center of the pelvis. The lettered transverse dimensions are defined in the text. At the present time only diameters *L*, *K*, *N*, and *T* are given in a routine pelvimetry report. *tt* is a vertical line passing 2 cm. lateral to the medial border of the greater trochanter when 36 inch anode-film distance is used and represents the table top for roentgenographic mensuration.

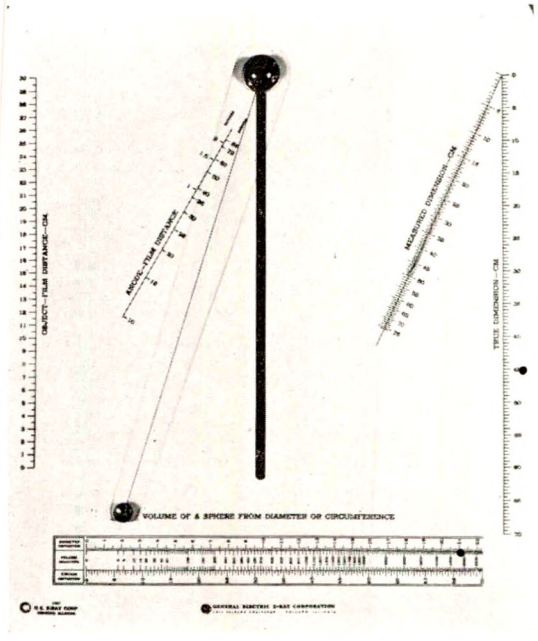


FIG. 5. Photograph of a nomogram (calculator) used to correct for magnification of film image in obstetrical pelvicephalometry. See text.

most portion of the amniotic sac. About 95 per cent are found in cephalic presentation. With this presentation, the most dependent part of the fetal cranium will lie nearly as low as the ischial spines in many cases. Others will show the fetal head dipping well into the pelvic inlet, except in a few instances. The exceptions are the ones most likely to have either soft tissue or bony dystocia. Even though the fetal head is not dipping below the pelvic inlet, it should be found normally in the median plane of the abdomen as seen in the anteroposterior view and in the midcoronal plane of the pelvic inlet as seen in the lateral view. When the head is found displaced laterally or anteroposteriorly a distance equal to about one-third the diameter of the cranium and not dipping into the pelvic inlet, the presence of a soft tissue mass holding the head out of the pelvis is suggested. The mass could be an ovarian cyst, a fibroid, an overdistended urinary bladder or sigmoid and, most important, it may be a low implantation of the placenta (placenta praevia[4]). In multiple pregnancies or breech presentations, the presenting part will not necessarily be found normally in the median plane of the pelvis.

During the exposure of roentgenograms taken in the manner described above, the fetal head and cardinal diameters of the pelvis are very nearly the same distances from the anode and from the film, consequently the magnification factor is very nearly the same for the fetal head and transverse pelvic diameters in the anteroposterior view as well as for the fetal head and the anteroposterior diameters in the lateral view. This spatial relationship makes it possible to utilize the fetal head for a "yardstick" in estimating fetal head-maternal pelvis ratio. The comparison can be made from flat films or stereoscopic roentgenograms. It is much preferable to have the fetal head shadow in close proximity to the pelvic diameters through which the fetus is to pass, as occurs in the erect position, rather than to make a stereoscopic comparison between the pelvis and the shadow of the fetal head lying high as it does in the horizontal posture. As stated previously, roentgenograms taken in the erect posture will permit this comparison in the majority of obstetrical cases examined in the last four to six weeks of pregnancy. Also observations on pelvic shape, prominence of the ischial spines and inclination of the sacrum can, of course, be made from the roentgenograms taken in the erect posture. For classification of the pelvic inlet according to the scheme of Caldwell and Moloy[5], a stereoscopic view as described above is necessary.

MENSURATION

Roentgenographic mensuration of the fetal head and maternal pelvis may be of practical clinical aid in some instances. Pelvic measurements should not be overemphasized since many factors enter into an obstetrical delivery. A relatively small fetal head in a large pelvis does not necessarily indicate an easy obstetrical delivery. Soft tissue dystocia, uterine inertia, malpresentation, and other factors may present a difficult obstetrical problem when the spatial relationship between the fetal head and maternal pelvis shows that no bony dystocia is present. Nevertheless, a comparison of the size of the fetal head with the dimensions of the maternal pelvis in quantitative units may serve a useful purpose in statistical analyses. An analysis of a large series of patients may reveal factors not heretofore appreciated. A report of this type of analysis will be the subject of a subsequent paper. The method which has been used to compute the measurements will be described in this report.

The roentgenograms taken in the anteroposterior and the lateral projection in the erect posture, as described above, are marked with a china pencil in the manner shown in Figures 3 and 4. The pelvic diameters in Figure 3 are all in the midsagittal (median) plane of the pelvis. They have the same magnification factor for that reason. A computation of the magnification would be a laborious process unless one used some type of nomogram. A previously described nomo-

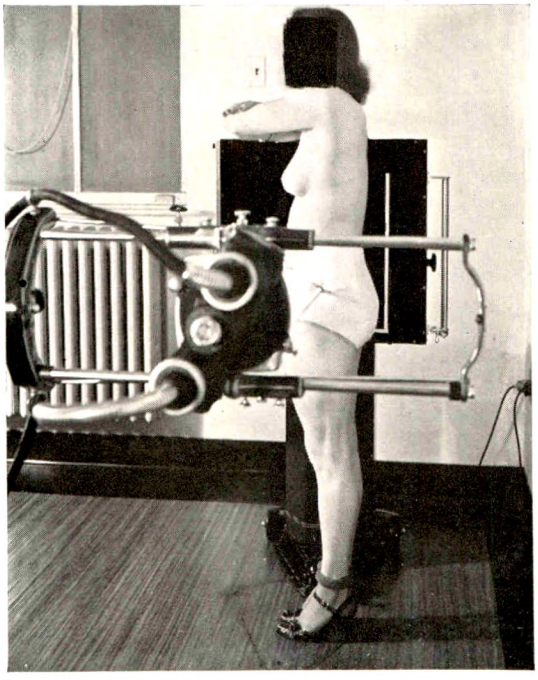


FIG. 1. Position of the patient for a lateral view of the pelvis in obstetrical roentgenography. The lower border of the film is on a level with the gluteofemoral fold. The sacrum is about 1 inch inside the lateral border of the film. The central rays are directed through the posterosuperior border of the hip joint. It is well to have the anode up and turned anteriorly to obtain the "bell effect" of the tube through the thickest part of the pelvis. The photograph shows the anode up but turned in the wrong direction.

lateral view, depending upon how pendulous the abdomen is or the quantity of amniotic fluid present.

To get a stereoscopic pair, a second roentgenogram may be made in the anteroposterior position with the tube shifted higher (3 inches for a 36 inch target-film distance). The first film, of course, is used for the measurements described below. If the abdomen is unusually pendulous or large, the second anteroposterior view in the erect posture can be omitted and stereoscopic roentgenograms taken with the patient supine. In the supine position, there will be less superimposed fluid and soft tissue present to interfere with good bone detail.

Breech Presentation. In a breech presentation an additional roentgenogram is made in the anteroposterior and also in the lateral view with the patient standing. These views are not taken until after the usual roentgenograms of the pelvis are developed and inspected, from which the level of the fetal head can be determined. The exposures are then made with size 14 × 17 inch films placed with the long axis horizontal and the central rays passing through the midcoronal and midsagittal planes of the body at the level of the fetal head. These exposures require about 85 kv. and 100 ma-sec., using "par speed" screens.

A filter heavier than those ordinarily used is desirable. We have found 5 mm. Al or 0.12 mm. Cu (0.001 in.) satisfactory with very little increase in exposure time.

INTERPRETATION OF THE ROENTGENOGRAM

When roentgenograms are taken with the patient standing, the fetus lies in the lower-

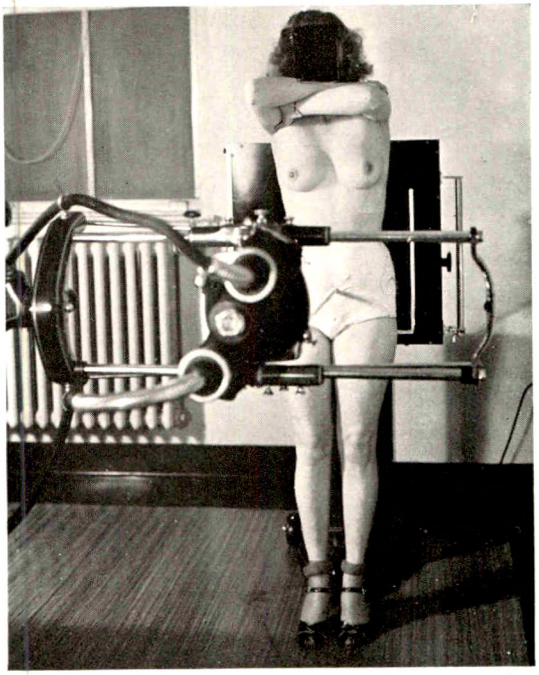


FIG. 2. Photograph showing the position of the patient for the anteroposterior view of the pelvis in obstetrical roentgenography. The vertical Potter-Bucky diaphragm remains at the same height. The tube height is unchanged. The central rays pass through the pelvis about 1 inch above the symphysis pubis. A vertical shift is used for a second exposure to obtain stereoscopic films.

VOL. 49, NO. 6

ROENTGENOGRAPHIC OBSTETRICAL PELVICEPHALOMETRY IN THE ERECT POSTURE*

By ROBERT P. BALL, M.D., *and* ROSS GOLDEN, M.D.
NEW YORK, NEW YORK

A METHOD of roentgen pelvimetry and of fetal cephalometry was described by one of us (R.P.B.)[1,2,3] which involved the determination of the volume of the fetal head from circumference measurements taken from right angle (anteroposterior and lateral) views. For a time the films were taken with the patient horizontal on the Potter-Bucky diaphragm table. For over five years the erect position has been used for this purpose in order to eliminate the possibility of a change in the relation of the uterus to the axis of the maternal body when the patient is turned from the anteroposterior to the lateral position. With the patient standing before an upright Potter-Bucky diaphragm the effect of gravity on the uterus and its contents is the same in both positions and the possibility of shift in the position of the fetal skull with the change in the position of the mother is eliminated.

It is the purpose of this paper (1) to describe the technique used in making the roentgenograms, and (2) to discuss their interpretation with particular reference to the quantitative relationship between the size of the fetal cranium and the maternal bony pelvis.

Two interesting by-products of the erect position observed with cephalic presentation which will be discussed below are (1) the "engagement" of the fetal head in the pelvic inlet through the pull of gravity, and (2) the displacement of the head by masses in the pelvis.

TECHNIQUE

Size 14 × 17 inch films are used in a vertical Potter-Bucky diaphragm. The long axis of the films is placed horizontal for anteroposterior views and vertical for the lateral view. A 36 inch anode-film distance is preferred, although other distances may be used.

Lateral View. The lateral view is taken first because of the convenience of external landmarks which can be used in alignment. The first step in this exposure is to align the patient with the film. The lower border of the film should be placed on a level with the gluteofemoral crease. The posterior border of the sacrum should be about 1 inch inside the lateral border of the film (Fig. 1). The second step in the lateral view is to center the roentgen tube. The central rays should pass through the posterosuperior margin of the acetabulum. A convenient external landmark for this point is about 1 inch above the superior margin of the greater trochanter. For the average size patient about 85 kv. and 400 ma-sec. will be required, using "par speed" screens, to obtain a good quality roentgenogram. Accurate centering will result in the practical superimposition of one sacrosciatic notch upon the other.

Anteroposterior View. For this view the height of the Potter-Bucky diaphragm and of the roentgen tube remain the same as for the lateral view. The patient turns at right angles to face the roentgen tube and is then placed with the midsagittal plane of the pelvis in the median plane of the film. The roentgen tube should be moved horizontally so that the central rays will pass through the median plane of the pelvis. The central rays will pass very near the superior margin of the symphysis pubis in this position (Fig. 2). The average patient will require 85 kv. and 200 ma-sec. exposure, using "par speed" screens, for good quality roentgenograms, but the exposure factors (ma-sec.) will be more variable than in the

* From the Department of Radiology of the Presbyterian Hospital and of the College of Physicians and Surgeons of Columbia University, New York.

due to a local rather than to a general effect such as might result from a nutritional disturbance or a hypoproteinemia. In this connection I should like to show you one case for which I am indebted to Dr. R. R. Newell of San Francisco. This patient had generalized amyloidosis and, at autopsy, amyloid deposits were present in the wall of the small intestine. The films showed a widening, coarsening and irregularity in the mucosal folds of the jejunum which is very similar to that demonstrated by Major Krause in the above mentioned case. This, of course, does not prove that the amyloidosis of the wall was responsible for the abnormal appearance but it is highly suggestive.

In addition to the scientific importance of these observations, Major Krause has helped the Army in getting some of these soldiers back to duty. He did not have time to bring out the fact that some of them were poor soldiers until the presence of real organic disease was demonstrated and proper treatment was instituted. I hope that Major Krause will have an opportunity some time to correlate the roentgen findings in these cases with the histologic picture of the intestinal wall.

These writers are to be congratulated on this important contribution.

Major Krause (closing). I should like to thank Major Pendergrass and Dr. Golden for their pertinent discussion. As Major Pendergrass brought out, those of us who have practiced in the northern half of the United States have never had to worry about intestinal parasites in our daily practice; but there are lots of northern boys in strange lands these days and they may bring back unfamiliar illnesses.

The question of the local action of the hookworm cannot be denied. However, we were inclined to minimize it somewhat, because with few exceptions, as in Figure 4, the changes were generalized throughout the small intestine. Dr. Strong, in his well known book on tropical diseases, indicates that almost all of the hookworms are localized in a relatively short portion of the gastrointestinal tract, namely, the middle third of the small intestine. It was therefore a little difficult for us to attribute these changes to local factors, but such factors must be considered and probably do form a part of the picture.

I was unable to have total serum protein determinations done, but no patient had edema and only three had red blood cell counts under two and one-half million. Only a handful of them were under three and one-half million. Otherwise all the rest of the patients had a high enough red cell count to eliminate clinically the probability of hypoproteinemia.

3. KANTOR, J. L. Roentgen diagnosis of idiopathic steatorrhea and allied conditions. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *41*, 758–778.
4. MACKIE, T. T., and POUND, R. E. Changes in gastro-intestinal tract in deficiency states, with special reference to small intestine. *J. Am. M. Ass.*, 1935, *104*, 613–618.
5. MACKIE, T. T., MILLER, D. K., and RHOADS, C. P. Sprue; roentgenologic changes in small intestine. *Am. J. Trop. Med.*, 1935, *15*, 571–589.
6. PENDERGRASS, E. P., and COMROE, B. I. Roentgen study of gastrointestinal tract in chronic idiopathic adult tetany. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 647–656.
7. PENDERGRASS, E. P., RAVDIN, I. S., JOHNSTON, C. G., and HODES, P. J. Studies of the small intestine. II. The effect of foods and various pathologic states on the gastric emptying and the small intestinal pattern. *Radiology*, 1936, *26*, 651–662.
8. SNELL, A. M., and CAMP, J. D. Chronic idiopathic steatorrhea; roentgenologic observations. *Arch. Int. Med.*, 1934, *53*, 615–629.
9. SNELL, A. M. Tropical and nontropical sprue (chronic idiopathic steatorrhea); their probable interrelationship. *Ann. Int. Med.*, 1939, *12*, 1632–1671.

DISCUSSION

MAJOR ROBERT C. PENDERGRASS, White Sulphur Springs, W. Va. I am delighted to have heard the presentation this morning, because since 1928 I have practiced radiology in a section where hookworm infestation is severe and during all these years I have missed the really significant changes occurring in these cases. We have observed in a great many of these cases marked irritability with reflux of the barium stream into the duodenum, but, unfortunately, no attention was paid to the small bowel pattern. I trust that this paper will not simply go on record as adding another causative factor to the deficiency pattern in the small bowel, but that it will be regarded as of clinical importance.

We have for a number of years in the South seen patients with vague abdominal complaints who have been diagnosed everything from peptic ulcer to chronic appendicitis, in whom hookworm has been found and whose symptoms have cleared up following treatment. With another sign of possible hookworm infestation added to our roentgenographic armamentarium, we should certainly bear in mind, when we see this pattern, that the patient may have such an infestation.

I should like to add one other brief remark. Major Krause stated that as a rule the ova disappear within six or seven years after the last infestation. We know from clinical experience that that is not always true and I have seen ova in adults as old as forty and forty-five years with symptoms of hookworm infestation.

There is one other point I should like to mention and that is that since *Necator americanus* inhabits chiefly the jejunum, we may begin to see within the next few years the tropical type of hookworm, since our troops are going into all sorts of climates and into all sorts of locations and some of these men may come back with infestation with the tropical type of hookworm, and it may be that then we will see roentgenological manifestations of disturbance of the duodenum rather than the jejunum.

I certainly wish to commend Major Krause for his careful study. It requires unusual zeal to carry out such a detailed investigation in addition to the routine work required in a large Army hospital.

DR. ROSS GOLDEN, New York, N. Y. We are to be congratulated on the opportunity to hear this excellent presentation. It is important, not only because Major Krause has shown that disturbances in the intestine caused by hookworm may be demonstrated by roentgenologic methods, but because further study may throw additional light on the mechanism of other intestinal disturbances. To this end it would be interesting to have information about the exact nature of the local lesions at the site of attachment of the worms to the wall. Major Krause, if I understood his statement correctly, was inclined to question whether there was a local disturbance due to the presence of the worm. It seems possible to me that there may be two factors concerned in this, one of which is local and the other general, such as a nutritional disturbance. Major Krause was not able to have serum protein examinations made in these cases but we know that a hypoproteinemia may be associated with severe anemia such as some of these patients had and that is one thing which can cause a profound disturbance in intestinal physiology.

In regard to the possibility of a local disturbance, his first slide showed a case in which there was only one loop of jejunum which was abnormal, and in that the mucosal folds were definitely widened and coarsened in marked contrast to the appearance of the other loops. That to me would suggest the possibility that it was

whether straight or converging, and of the subpubic arch, i.e., whether wide or narrow and whether the top is rounded or sharp. The description of the shape of the subpubic arch is based largely on a roentgenogram taken with the tube angled 45 degrees upward through the pubis, as described by Caldwell, Moloy and Swenson;[6] the width of the base of this arch is reflected in the subpubic arch measurement, which, however, does not indicate the character of its top. The measurements of the inlet by themselves do not necessarily indicate its ability to transmit the fetal head but must be considered in conjunction with its shape; a small well rounded inlet (gynecoid type) may give no trouble while if the widest point of the inlet is placed farther back toward the sacrum (android type) great difficulty in engagement may be encountered.

The practical clinical application of quantitative studies of the pelvis and fetal head has been found useful. In any pelvis, the obstetrical conjugate *B* (Fig. 3) or the biischial spine diameter *K* (Fig. 4) will be the smallest internal pelvic diameter. However, in rare instances, these two diameters may be very nearly equal. If the mean circumference measurement of the fetal head plus scalp is translated into units of volume, milliliters, it can be compared to the volume capacity of one of these internal pelvic diameters, i.e., to the volume of the largest sphere which could pass through. (See Figure 6 for comparison of volume of a sphere determined from circumference measurements and from diameter measurements.) When the volume of the fetal head is less than the volume capacity of *either of these diameters*, there is no bony disproportion present. The volume of the fetal head can be larger than the volume capacity of either diameter without necessarily signifying the presence of important bony disproportion provided (1) that moulding of sufficient degree can occur thus reducing the size of the head in the direction of the narrow diameter, or (2) that compensatory space is present so that the widest portion of the fetal head does not have to pass through the narrowest diameter of the pelvis. Because of the variables involved namely (1) uterine force, (2) moulding, and (3) amount of compensatory space, arbitrary limits cannot be set. In general, however, the smaller the pelvis and the greater the difference between the volume of the fetal head and the volume capacity of the smallest pelvic dimension, the greater is the danger of serious difficulty in delivery and the more skill required of the obstetrician.

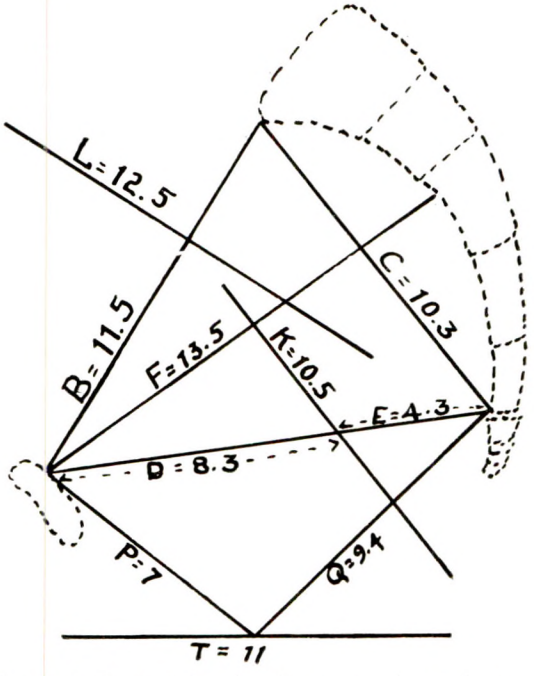


Fig. 9. A diagram showing the average in centimeters of the internal pelvic dimensions of 349 obstetrical patients. This diagram is useful for comparing any particular pelvis with an average. This type of diagram drawn to scale may be included in an obstetrical report to illustrate better the anatomical characteristics of the pelvis. At the present time our written reports include *B*, *L*, *K*, *T*, *D*, and *E*; the measurement *N* in Figure 4 is not indicated on this diagram.

The presence or absence of compensatory space can be ascertained by inspection of the roentgenograms, particularly in the stereoscopic views, or may be indicated by the measurements of other pelvic dimensions at the same approximate level. The

purpose, of course, is to obtain an idea of the cross section area. Reference to the average dimensions of certain internal pelvic diameters will quickly disclose wherein any particular pelvis differs from the average. Figure 9 is a diagrammatic representation of the average dimensions of 349 obstetrical patients examined in the Department of Radiology of the Presbyterian Hospital in New York City. In Figure 9, it will be noted that transverse dimensions are placed in such a manner as to be intersected by the median plane. This is merely a convenient manner of disclosing graphically certain anatomical characteristics of the pelvis. At the first inspection, the diagram may not have much meaning but, when one attempts to visualize the position and relative size of the transverse dimensions in relation to those in the median plane shown in the lateral view, it will appear logical. This type of diagram has been used in our reports and conveys both the actual pelvic dimensions drawn to scale and certain anatomical characteristics of the pelvis.

Pelvic diameters of no immediate clinical importance are of significance for anthropological studies and for statistical analysis. Indices may be obtained from certain dimensions which reflect pelvic shape and capacity. For example, an index can be obtained from the biischial spine diameter (K) and the sagittal diameter of the fore pelvis (D), called the D/K index. Let D (Fig. 3) be the numerator and K (Fig. 4) be the denominator of a fraction and multiply the result by 100. This represents a horizontal (with the patient erect) cross section of the pelvis at the level of the ischial spines with K as the base and D as the altitude of an elliptical periphery. Obviously an index of over 100 is produced when the altitude (anteroposterior diameter of fore pelvis) is greater than the base (interspinous diameter) of this cross section, and conversely an index of less than 100 is produced when the base is greater than the altitude. In a large series of obstetrical patients, the D/K index was found to average from 80 to 85. In a series of male pelves, the average D/K index was close to 96. A statistical analysis of pelvic dimensions and certain indices, correlated with fetal head size, pelvic type and the function of childbirth will be the subject of a subsequent report.

SUMMARY

The erect position has definite advantages for pelvicephalometry. Gravity does not change the position of the uterus when the patient turns from the anteroposterior to the lateral positions as it does when she is horizontal and hence true right angle views of the fetal head are obtained. In cephalic presentation, the fetal head will assume the lowermost position possible and is often found lying deep in the pelvis, showing that engagement takes place without difficulty. Failure of the head to dip into the pelvis and lateral displacement from the middle of the pelvis in the anteroposterior view, when the patient is near term, suggest the presence of a mass of some sort in the pelvis, possibly placenta praevia.

A method of mensuration of the maternal pelvis and fetal head, from roentgenograms taken in the erect posture, is described and certain pelvic dimensions are defined which are of importance for statistical analysis and for practical clinical purposes.

A diagram from the lateral projection to scale may serve a twofold purpose in reporting obstetrical cases. First, it gives a graphic representation of the particular pelvis and second, it permits a comparison with a normal average. In making a comparison it graphically discloses wherein a particular pelvis differs from another and shows the presence or absence of compensatory space in borderline cases.

Arbitrary limits of safety in pelvic dimensions cannot be set because of the variables involved in the function of childbirth (uterine force, amount of moulding, availability of compensatory space). As a general principle, however, it can be stated

that the smaller the pelvis and the greater the excess of fetal head volume over the volume-capacity of the smallest pelvic diameter, the greater the danger of difficulty. It is our impression that in borderline cases, the procedure described above serves much more frequently to show the obstetrician that engagement and delivery can probably occur than to aid him positively in deciding on elective cesarean section.

REFERENCES

1. Ball, R. P., and Marchbanks, S. S. Roentgen pelvimetry and fetal cephalometry; a new technic. *Radiology*, 1935, *24*, 77–84.
2. Ball, R. P. Roentgen pelvimetry and fetal cephalometry. *Surg., Gynec. & Obst.*, 1936, *62*, 798–810.
3. Ball, R. P. Pelvicephalometry. *Radiology*, 1938, *31*, 188–197.
4. Ball, R. P., and Golden, R. Roentgenologic sign for detection of placenta previa. *Am. J. Obst. & Gynec.*, 1941, *42*, 530–533.
5. Caldwell, W. E., and Moloy, H. C. Anatomical variations in the female pelvis and their effect in labor, with suggested classification. *Am. J. Obst. & Gynec.*, 1933, *26*, 479–505.
6. Caldwell, W. E., Moloy, H. C., and Swenson, P. C. Use of the roentgen ray in obstetrics. 1. Roentgen pelvimetry and cephalometry; technique of pelvioroentgenography. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 305–316.
7. Holmquest, H. J. Nomogram for roentgenographic mensuration. *Radiology*, 1938, *31*, 198–205

ANALYSIS OF ROENTGEN PELVIMETRY BY THE JOHNSON STEREOROENTGENOMETER IN 379 CASES

By J. N. ANÉ, M.D., *and* LEON J. MENVILLE, M.D.
Division of Radiology, Department of Medicine, Tulane University
NEW ORLEANS, LOUISIANA

IN 1927, Johnson[4] described a practical method of stereoroentgenometry, similar in principle to the Mackenzie Davidson[3] method of opaque foreign body measurement and the Manges[7] modification of this original method for roentgen pelvimetry. As the result of subsequent improvements by Johnson,[5,6] this method is now accepted as one of the most popular and accurate methods of roentgen pelvimetry in use.

It was believed that it would be of interest to determine the average diameters of the pelvis and also to attempt to analyze the contracted diameters and the plane or planes in which they existed when correlated with the clinical course of the pregnancies.

This study includes the measurements of the pelvic diameters obtained in 450 consecutive obstetrical patients. With few exceptions, these individuals were primiparas. The principle of this method and the details of the technique have been described by Johnson.[4]

The average diameters of the 450 cases studied are shown in Table I. It will be noted that the averages obtained for this group of cases agree closely with those of Williams and of DeLee, with the exception of the true conjugate which is somewhat greater than the 11 cm. considered by these authors as normal. This consistent increase of the true conjugate of the pelvic inlet as determined by roentgen-ray measurements over clinical measurements has been noted by Rappaport and Scadron.[8]

It may be noted in Table II that of the 450 cases, 241, or 53.5 per cent, had pelvic diameters which were considered normal; 130, or 28.9 per cent, showed contraction in one or more diameters of from 5 to 10 mm.; and 79 cases, or 17.5 per cent, showed shortening in one or more diameters of more than 10 mm.

In an effort to correlate the value of this method of roentgen pelvimetry with clinical results, reports of the subsequent courses of the pregnancies were requested from the obstetricians referring the patients. In this manner it was possible to obtain information relative to the types of deliveries in 379 patients.

Analysis of the pelvic diameters obtained by stereoroentgenometry in these 379 cases

TABLE I

AVERAGE PELVIC DIAMETERS

	Cases Measured	Cases of Normal Deliveries Reported
Number of Cases	450	290
Inlet:		
Anteroposterior (true conjugate)	11.88 cm.	11.81 cm.
Transverse	13.56 cm.	13.65 cm.
Right oblique	12.92 cm.	13.03 cm.
Left oblique	12.92 cm.	13.06 cm.
Mid-plane (plane of least pelvic diameters):		
Anteroposterior	11.41 cm.	11.73 cm.
Transverse (interspinous)	10.30 cm.	10.44 cm.
Posterior sagittal	4.03 cm.	4.34 cm.
Outlet:		
Anteroposterior (to tip of sacrum)	11.41 cm.	11.73 cm.
Anteroposterior (to tip of coccyx)	9.51 cm.	9.52 cm.
Transverse	11.13 cm.	11.31 cm.
Posterior sagittal	7.09 cm.	7.47 cm
Fetal skull:		
Fronto-occipital	11.22 cm.	11.30 cm.
Suboccipitobregmatic	9.31 cm.	9.41 cm.

TABLE II

CLASSIFICATION OF CASES

Groups	450 Cases Measured		379 Cases Reported	
	No. of cases	Per cent	No. of cases	Per cent
Normal diameters	241	53.5	216	56.9
Cases in which one or more diameters were contracted from 5 to 10 mm.	130	28.9	95	25.1
Cases in which one or more diameters were contracted more than 10 mm.	79	17.5	68	17.9

(Table II) showed that in 216, or 56.9 per cent, all diameters were normal or greater than the accepted average diameters; in 95 patients, or 25.1 per cent, one or more diameters were shortened from 5 to 10 mm.; and in 68 cases, or 17.9 per cent, diameters were contracted over 10 mm.

Table III is a summary of the three groups of cases and the types of deliveries which occurred. Two hundred and ninety, or 76.5 per cent, of the entire group of 379 patients delivered normally. Seventy-two, or 18.9 per cent, had abnormal deliveries because of pelvic contraction or bony disproportion.

TABLE III

SUMMARY OF REPORTED CASES

Classification of Cases	No. of Cases Reported	Sections and Forceps Deliveries for Indications Other than Disproportion	Corrected No. of Cases	Normal Deliveries	Cesarean Sections	Forceps Deliveries	Difficult Deliveries	Early Induction
Normal measurements Per cent	216	11	205	203 99.0%	1 0.49%	1 0.49%	0	0
Cases in which one or more diameters were contracted from 5 to 10 mm. Per cent	95	4	91	73 80.2%	3 3.3%	8 8.8%	6 6.6%	1 1.0%
Cases in which one or more diameters were contracted more than 10 mm. Per cent	68	2	66	14 21.2%	47 71.2%	4 6.0%	1 1.5%	0
Total	379	17		290	51	13	7	1
Per cent (all cases)		4.5		76.5	13.4	3.4	1.8	0.3

Of these 72, 51, or 13.4 per cent, had cesarean sections; 13, or 3.4 per cent, had high or mid forceps deliveries; 7, or 1.8 per cent, had prolonged or difficult labors due to pelvic contraction; and in one case an early induction of labor was performed. The remaining 17 cases of this group had cesarean sections or forceps deliveries for indications other than bony disproportion. The average pelvic diameters of the 290 patients who had normal deliveries are shown in Table I.

Table IV is a study of the 216 patients who had normal or greater than average measured diameters as determined by stereoroentgen pelvimetry. Of these, 203 delivered normally. Episiotomies and low forceps deliveries were considered normal for this study and are therefore included in this group, which, as was previously mentioned, consisted of primiparas with few exceptions. Three patients had forceps deliveries: 2 for indications other than bony disproportion, and in the remaining case an 8 pound, 5 ounce baby was delivered from a pelvis of average diameters (the fronto-occipital diameter of the skull measured 11.8 cm. several weeks before delivery). Ten cases were delivered by cesarean section: 1 because of placenta previa, 1 because of brow presentation, 1 because of rupture of the uterus, 6 because of cervical dystocia, and 1 because of apparent bony disproportion. The pelvic diameters of this last patient were not greater than the average (i.e., anteroposterior of the outlet 11.4 cm., interspinous 10.5 cm.) and the fetal skull measured 11.9 cm. in fronto-occipital diameter and 9.7 cm. in the suboccipitobregmatic diameter several weeks before delivery. If the 9 patients delivered by cesarean section and the 2 by forceps for indications other than bony disproportion are excluded from this group, there remain 205 patients with normal measurements, of which 203, or 99.0 per cent, delivered normally and 2, or 1 per cent, had abnormal deliveries. Therefore, it would appear that if the diameters obtained by the Johnson method of stereoroentgenometry are found to be normal, the accuracy of this method in the determination should be about 99 per cent.

TABLE IV

CASES IN WHICH THE PELVIC DIAMETERS WERE FOUND NORMAL OR GREATER THAN AVERAGE

No. of Cases Reported	Sections and Forceps Deliveries for Indications Other than Disproportion					Corrected No. of Cases	Normal Deliveries	Forceps Deliveries	Cesarean Sections
	Forceps	Cesarean sections							
	Posterior position	Brow presentation	Rupture of uterus	Cervical dystocia	Placenta previa				
216	2	1	1	6	1	205	203	1	1
Per cent							99.0	0.49	0.49

Table V is an analysis of the 95 patients who had one or more diameters shortened from 5 to 10 mm. The contracted diameters are listed to the left of the table. As would be expected in this group, in many cases there was sufficient increase in one or more of the other diameters to compensate for the moderately contracted diameter or diameters. Seventy-three patients, or 80.2 per cent, delivered normally; 3 cases, or 3.3 per cent, had cesarean section; 8, or 8.8 per cent, were delivered by forceps; 6, or 6.6 per cent, had unusually prolonged and difficult labor; and 1 had an early induction of labor. There were 3 cesarean sections and 1 forceps delivery in this group for indications other than bony disproportion.

TABLE V

CASES IN WHICH ONE OR MORE DIAMETERS WERE CONTRACTED FROM 5 TO 10 MM.

Plane of Pelvis in Which Contraction Existed						Indicated Because of Disproportion			Indications Other than Disproportion	
Inlet	Mid-plane	Outlet	No. cases	Normal deliveries	Difficult deliveries	Section	Forceps	Early induction	Section	Forceps
A.P.	Normal	Normal	1	1						
A.P.	Trans.	Normal	1						1	
A.P.	A.P.	A.P.	3	3						
Trans.	Normal	Normal	4	4						
Trans., R.O., L.O.	Normal	Normal	2	1	1					
Trans., R.O., L.O.	A.P.	A.P.	2	1		1				
Trans., R.O.	A.P., Trans.	A.P., Trans.	2			1	1			
Trans., R.O., L.O.	Trans.	Trans.	1	1						
Trans., R.O.	Trans.	Trans.	3	2		1				
Trans.	Trans.	Trans.	11	7			4			
Trans.	A.P., Trans.	A.P., Trans.	2	1				1		
Trans.	A.P., Trans.	A.P.	1	1						
Trans.	A.P.	A.P.	4	3	1					
Trans.	A.P.	A.P., Trans.	3	3						
Trans.	Trans.	Normal	6	5	1					
R.O., L.O.	A.P., Trans.	A.P., Trans.	1	1						
Trans.	Normal	Trans.	1				1			
R.O., L.O.	Normal	Normal	1	1						
R.O., L.O.	Normal	Trans.	1							1
R.O.	Trans.	Trans.	1	1						
L.O.	A.P.	A.P.	2	2						
L.O.	A.P., Trans.	A.P., Trans.	3	2	1					
Normal	A.P., Trans.	A.P.	6	4			1		1	
Normal	A.P., Trans.	A.P., Trans.	2	2						
Normal	A.P.	A.P.	11	11						
Normal	A.P.	A.P., Trans.	2	2						
Normal	Trans.	Normal	7	6					1	
Normal	Trans.	Trans.	8	5	2		1			
Normal	Normal	Trans.	3	3						
Total (all cases)			95	73	6	3	8	1	3	1
Total (excluding sections and forceps delivery for indications other than disproportion)			91	73	6	3	8	1		
Percentage				80.2	6.6	3.3	8.8	1.0		—

A.P. = anteroposterior; Trans. = transverse; R.O. = right oblique; L.O. = left oblique.

In Table VI are included the 68 patients in whom pelvimetry revealed one or more diameters shortened or contracted more than 10 mm. The contracted diameters are listed in the three columns to the left of the table. It will be noted that 47 patients, or

TABLE VI

CASES IN WHICH ONE OR MORE DIAMETERS WERE CONTRACTED MORE THAN 10 MM.

Plane of Pelvis in Which Contraction Existed						Indicated Because of Disproportion			Indications Other than Disproportion	
Inlet	Mid-plane	Outlet	No. cases	Normal delivery	Difficult delivery	Section	Forceps	Early induction	Section	Forceps
A.P.	A.P.	A.P.	1			1				
A.P., Trans., R.O., L.O.	A.P., Trans.	A.P., Trans.	1			1				
A.P., Trans., R.O., L.O.	A.P.	A.P.	1	1						
A.P., Trans.	A.P., Trans.	A.P., Trans.	2			2				
A.P., R.O. L.O.	A.P.	A.P.	2	1	1					
A.P.	A.P., Trans.	A.P., Trans.	2			2				
A.P., Trans.	Trans.	Trans.	1			1				
Trans., R.O. L.O.	A.P.	A.P.	1			1				
Trans., R.O., L.O.	A.P.	A.P., Trans.	1			1				
Trans., R.O., L.O.	A.P., Trans.	A.P., Trans.	5	2		2			1	
Trans., R.O., L.O.	A.P., Trans.	A.P.	1			1				
Trans., R.O., L.O.	Trans.	Trans.	3			3				
Trans., R.O.	Trans.	Trans.	1			1				
Trans., L.O.	A.P., Trans.	A.P., Trans.	2	1		1				
Trans., L.O.	Trans.	Normal	1			1				
Trans.	A.P., Trans.	A.P., Trans.	5			4	1			
Trans.	Trans.	Trans.	7			6	1			
Trans.	Trans.	Normal	1			1				
Trans.	A.P., Trans.	A.P.	2			2				
Trans.	A.P.	A.P.	2	1					1	
Trans., R.O.	A.P.	A.P.	1			1				
R.O., L.O.	A.P.	A.P.	2			2				
R.O.	A.P.	A.P.	1			1				
L.O.	A.P.	A.P.	1			1				
R.O.	Trans.	Trans.	2			2				
R.O., L.O.	A.P.	A.P., Trans.	1			1				
Normal	A.P., Trans.	A.P.	1			1				
Normal	A.P., Trans.	A.P., Trans.	2			2				
Normal	Trans.	Trans.	6			5	1			
Normal	A.P.	A.P.	7	7						
Normal	A.P.	A.P., Trans.	2	1			1			
Total (all cases)			68	14	1	47	4	0	2	0
Total (excluding sections for indications other than disproportion)			66	14	1	47	4			
Percentage				21.2	1.5	71.2	6.0			

A.P. = anteroposterior; Trans. = transverse; R.O. = right oblique; L.O. = left oblique.

71.2 per cent, were delivered by cesarean section and that 4, or 6.0 per cent, had deliveries by forceps. Fourteen, or 21.2 per cent, delivered normally while 1 case had a prolonged and difficult labor. Two patients were delivered by cesarean section for indications other than pelvic contracture. It is of interest that this group includes 7 cases with contraction of over 10 mm. of the tion of the interspinous diameter of over 10 mm., only 3, or 6.6 per cent, delivered normally. Thirty-eight, or 84.4 per cent, were delivered by cesarean section while 3 patients, or 6.6 per cent, had forceps deliveries.

For the purpose of pelvimetry the pelvis may be divided into three planes. These are the inlet or superior strait, the mid-plane or

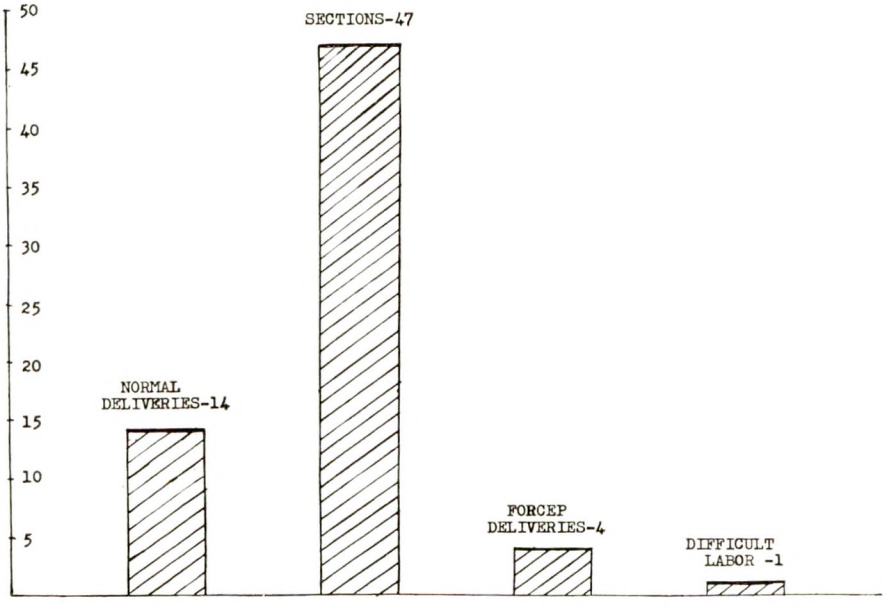


Chart I. Results in cases in which one or more diameters were contracted more than 10 mm.

anteroposterior diameters of the mid-plane and outlet only. This diameter is measured from the tip of the sacrum to the inferior symphysis pubis and serves as the anteroposterior diameter of both planes. In each one of the 7 cases the other diameters of the pelvis were normal or above the average and each of the 7 cases delivered normally. However, when the contraction of this diameter was complicated by the shortening of one or more of the other diameters, abnormal delivery resulted in the great majority of the cases. The final results of the pregnancies in this group are shown diagrammatically in Chart 1.

This study has emphasized the importance of the interspinous or transverse diameter of the mid-plane in pelvimetry (Chart 11). Of the 45 patients with contracplane of least pelvic diameters, and the outlet or inferior strait. The following diameters were measured:

Inlet:

Anteroposterior: Measured from the sacral promontory to the superior symphysis pubis.

Transverse: Measured across the greatest width of the pelvic brim at right angles to the true conjugate.

Right Oblique: Measured from the right sacroiliac articulation at the pelvic brim to the left iliopectineal eminence.

Left Oblique: Measured from the left sacroiliac articulation at the pelvic brim to the right iliopectineal eminence.

Mid-plane:

Anteroposterior: Measured from the tip of the sacrum to the inferior symphysis pubis.

Transverse: Measured between the ischial spines.

Posterior Sagittal: Measured from the tip of the sacrum to the center of the interspinous diameter.

Outlet:

Anteroposterior to the Sacrum: Measured from the tip of the sacrum to the inferior symphysis pubis.

Anteroposterior to the Coccyx: Measured from the tip of the coccyx to the inferior symphysis pubis.

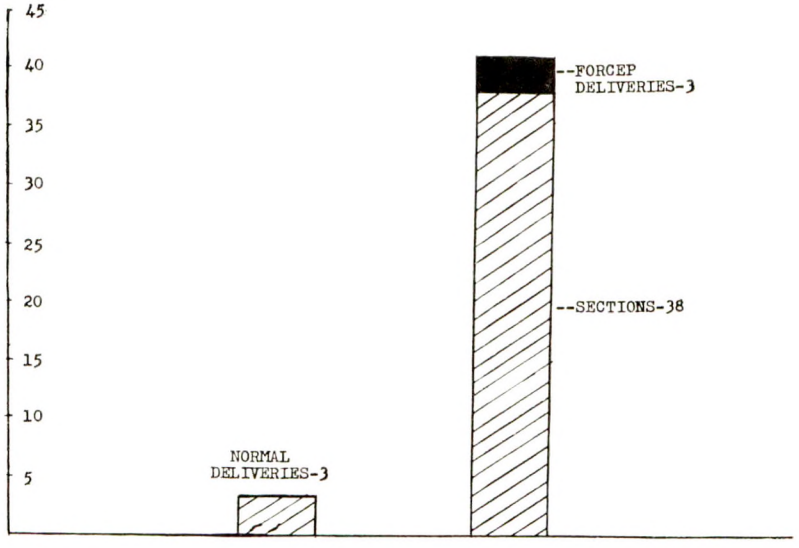


CHART II. Results in cases in which the interspinous diameters (mid-plane) were contracted more than 10 mm.

Transverse: Measured between the ischial tuberosities.

Posterior Sagittal: Measured from the tip of the sacrum to the mid-point of the transverse diameter.

Measurements of the posterior sagittal diameters of the mid-plane and outlet have been made routinely for a shorter period and we have not attempted to evaluate these diameters in this series of cases. However, in the cases followed we are in agreement with Johnson that when the sum of the posterior sagittal and the transverse diameters of the outlet is 17 cm. or more little or no difficulty should be expected from disproportion. We are unable at this time to make any mathematical statement regarding the relation of the posterior sagittal of the mid-plane to the interspinous diameter.

No attempt has been made in this study to obtain postpartum measurements of the fetal skull in each case. However, the diameters of the skull are routinely measured at the time roentgen pelvimetry is done, which is ordinarily about two weeks before the expected date of delivery. In less than 5 per cent of cases fetal movement has prevented accurate measurements of the fetal skull. This has been found especially true in breech presentations. It is believed that the factor of fetal movement would interfere with fetal skull measurements by any technique or method employed but that the evidence of such movement is better observed on films viewed stereoscopically. In a small series of cases in which head measurements were obtained after delivery, the accuracy of the method proved highly satisfactory.

One of the important advantages of stereoroentgenometry is the stereoscopic visualization of the relationship of the fetal skull to the bony pelvis. Very much valuable information can be obtained from

ROENTGENOLOGIC LOCALIZATION OF THE PLACENTA WITHOUT CONTRAST MEDIA*

By R. MANGES SMITH, M.D.
PHILADELPHIA, PENNSYLVANIA

THE purpose of this presentation is to describe a roentgenologic method of determining the position of the placenta without administering or utilizing opaque media. I am led to believe that such knowledge of placental location is often of value to the obstetrician, and presume if the information can be secured without disturbance to the mother or fetus that such would be additionally desirable.

It has been the general understanding of roentgenologists and clinicians that the soft tissue of the uterus and of the secundines cannot be visualized by the ordinary methods of roentgen study. For this reason, various types of opaque medium and various methods of their introduction have been employed during the past twenty-five years. This work was first inaugurated by Carey, who, in 1914, published a short preliminary note on the determination of patency of the fallopian tubes by the use of collargol. This article was followed, in a short time, by a very complete report of roentgen diagnosis in gynecology with the aid of intrauterine collargol by Rubin, in 1915. Whether these two made the first attempt to demonstrate the contours of the uterus by opaque media is open to some conjecture, although their publications were certainly the first to appear in the literature. In 1912, Le Lorier made intrauterine injections of electrargol in order to determine the patency of the tubes, and presented his work at the Congress of Lille, in 1913, but did not publish it Early work in this field was also done in Pozzi's Clinic by Dernier. Dernier used collargol and the patient developed peritonitis. After this untoward reaction the method was discontinued at Pozzi's advice.

Following these pioneer efforts in visualization of the uterus and tubes, there occurred a rapid development both in method and in media. First to employ lipiodol in this field was Carlos Heuser, of Buenos Aires. Heuser applied this method of study to the diagnosis of pregnancy, having the temerity to inject lipiodol solution through the cervix into the pregnant uterus. He affirmed that this method of study had provoked no disturbance of the pregnancy and that by means of it he was able to outline the peculiar contours of the implanted ovum. Those who undertook to follow his suggestions discovered, however, that the production of miscarriage was very common. Miller and Martinez reported 3 cases of abortion among 15 cases which were studied by the Heuser method. As a result of these cases, the injection of media through the cervical channel during pregnancy was abandoned.

The next step in the history of this field of roentgenology occurred when Menees, Miller and Holly reported a series of cases in which they had injected a radiopaque solution through the abdominal wall into the amniotic cavity, by means of which the outline of the fetus and the contour of the placenta were made visible; in fact, so effective was the contrast medium that in many instances they were able to determine the loops of cord around the neck, and the sex of the fetus. For purposes of their study some 10 to 15 cc. of a 1 to 1 solution of U.S.P. strontium iodine solution in water was used. They reported 21 cases with no injuries or toxic effects in the mother. In one instance a low implanted placenta was perforated and the patient started in labor. They suggested that the method would be of value in the diagnosis of placenta praevia. This method of examination was tried out by several other clinics with less favorable results than had been reported by the orig-

* From the Department of Roentgenology, Jefferson Medical College Hospital.

such a study as shown by Caldwell and Moloy.[1,2] The study and classification of the pelvic type correlated with the study of the diameters obtained by stereoroentgen pelvimetry offers information of the greatest value to the obstetrician.

SUMMARY AND CONCLUSIONS

1. In a series of 205 patients with normal diameters as determined by stereoroentgen pelvimetry, 203, or 99 per cent, delivered normally.

2. In a group of 61 patients in whom more than one pelvic diameter were contracted more than 10 mm., 52, or 85.2 per cent, had difficult or prolonged labors or required operative deliveries.

3. The Johnson method of stereoroentgenometry combined with the stereoscopic study of the relationship of the bony pelvis and the fetal skull are of considerable value in the prognosis of the future course of pregnancy.

REFERENCES

1. Caldwell, W. E., and Moloy, H. C. Anatomical variations in the female pelvis and their effect in labor with a suggested classification. *Am. J. Obst. & Gynec.*, 1933, *26*, 479–505.
2. Caldwell, W. E., Moloy, H. C., and D'Esposo, D. A. Further studies on the pelvic architecture. *Am. J. Obst. & Gynec.*, 1934, *28*, 482–497.
3. Davidson, Sir James Mackenzie. Localization by X-Rays and Stereoscopy. P. B. Hoeber, New York, 1916.
4. Johnson, C. R. Mensuration and localization by means of the roentgen ray. *Radiology*, 1927, *8*, 518–521.
5. Johnson, C. R. Stereoroentgenometry; method for mensuration by means of the roentgen ray. *Am. J. Surg.*, 1930, *8*, 151–163.
6. Johnson, C. R. Pelvimetry by stereoroentgenometry. Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 607–619.
7. Manges, W. F. Description of method of measuring female pelvis. Am. Quart. Roentgenol., 1911, *3*, 41–43.
8. Rappaport, E. M., and Scadron, S. J. Pelviradiography and clinical pelvimetry; comparative values in prognosis of outcome of labor. *J. Am. M. Ass.*, 1939, *112*, 2492–2497.

thelial structure. For this reason it finds its way rapidly into the placenta and there casts a very decided shadow upon the roentgenogram. Thus far the method has not been acceptable for use in the human being, and has been limited to animal experimentation, for it has been found that the presence of the opaque medium in the placental structure interferes with the vitality and intrauterine life of the fetus, and in most experimental animals the fetus has eventually died in utero.

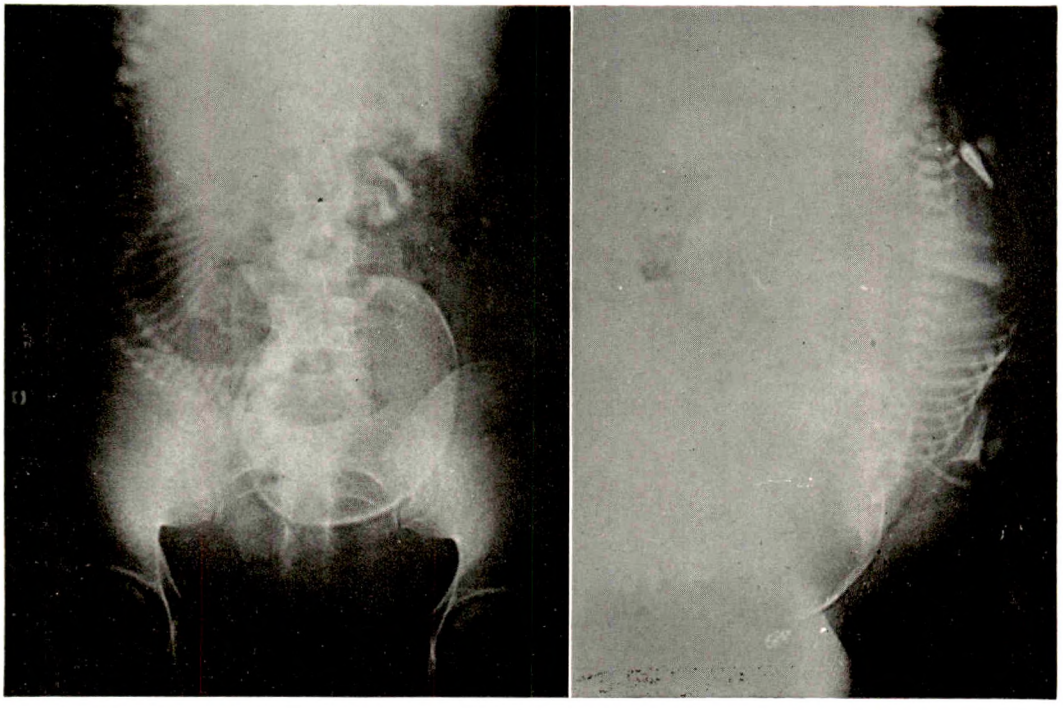


FIG. 1. Placenta praevia. Note absence of placental shadow in lateral view, and upward displacement of fetal head in anteroposterior view.

My interest in the problem of placental localization dates from the period of amniography and started with studies which the Obstetrical Department of the Jefferson Hospital and the Roentgenological Department undertook in 1931 to confirm the observations of Menees *et al.* The injections were made in the Obstetrical Department and roentgenograms were taken in our department. We were able to achieve excellent visualization of the fetus and of the placenta and, from the standpoint of roentgenology alone, the method was an entire success. Obstetrically, however, the method proved exceedingly dangerous. In one instance in which sodium iodide was used through error, the fetus immediately succumbed. In several instances the surface of the fetal body was traumatized by the injection needle and in the majority of cases labor started within twenty-four to thirty-six hours after the injection of the opaque material. In 2 instances the placenta was perforated and the fetus stillborn. Naturally, this method was promptly and permanently abandoned.

While examining these roentgenograms, having before me so clearly the placental area, I began comparing with them some of the roentgenograms of pregnant women which had been taken without contrast medium, and much to my surprise I found that certain zones of the uterine body which I had taken to be amniotic fluid corresponded to the placental site and presented certain features which upon further

inal workers. Burke employed the method in a series of cases and reported his results in 1935. He used uroselectan B instead of strontium iodide and secured very successful roentgenograms of the fetus and secundines. Burke felt that the method had value in the diagnosis of placenta praevia, but warned or its effect in inciting labor. He found that labor started in every instance, except one of hydramnios, within twenty-four to forty-eight hours after the injection was made, although he had no case of maternal or fetal injury in 75 cases.

Adair and Davis reported their results with skiodan for amniography in 1933, and their conclusions were that the results obtained scarcely justified the risks that were associated with the undertaking. Cornell and Case, in their report in 1934, considered that the method has a limited field and has actual dangers. In spite of their best effort to avoid the placental site in making the injection, they found that the needle had punctured the placenta in 6 cases. In a final discussion, Cornell stated that he would consider it wise to discontinue the intrauterine injection of opaque medium during pregnancy. So discouraging were these various results and reports that amniography with the use of opaque medium has been almost completely abandoned.

The contributions of Ude, Weum and Urner constitute the next chapter in the roentgenological diagnosis of placenta praevia. The preliminary report of these investigators was published in 1934. They recommended the introduction of opaque medium into the bladder, suggesting specifically the use of 40 cc. of a 12.5 per cent solution of sodium iodide as a contrast medium. Anteroposterior and lateral roentgenograms were taken and the relationship of the fetal presenting head of the bladder was carefully noted. Unusual separation of the head from the bladder or unusual deformity of the bladder was taken to indicate the presence of intervening soft tissue which was presumed to be placenta. In the majority of cases in which these characteristic findings were noted the diagnosis was confirmed either by the clinical course of vaginal delivery and the condition of the placenta or by the findings upon cesarean section.

Further cases were reported by Ude and Urner in 1935 and the authors state, upon the basis of their ample experience that "We have found that the presenting head invariably lies directly against the lower anterior wall of the uterus unless it is displaced upward by a solid mass, either by the placenta, blood clots from a premature separation of the placenta, or from some abnormality of the fetus or pelvis." The work of Ude and Urner has received wide and favorable comment and a number of publications have confirmed the accuracy and usefulness of the method (Priest, McIver, Friedman and Macdonald, Wells, McDowell, Hall, Currin and Lynch and others).

The method, however, does not provide for the diagnosis of position of the placenta when there are abnormal presentations such as the breech, the shoulder, etc., nor does it provide for a differential diagnosis of high displacement of the head in a contracted pelvis. These shortcomings are acknowledged freely by the original authors. In addition, several observers have noted cases where the presenting part has been displaced above the bladder and no evidence of placenta praevia was found. Such observations are reported by Hundley *et al.* in a contribution on the physiological changes occurring in the urinary tract during pregnancy. In studying the urinary tract, after intravenous pyelography, they found in 10 of 27 patients a space between the shadow of the fetal head and the outline of the bladder which varied from 1 to 2.5 cm. in thickness. In none of these 10 cases was placenta praevia found to be present.

In very recent years an endeavor has been made to bring out the contour of the placenta by the injection of thorotrast. This material, administered intravenously, is taken up by the lymphatics of those organs which are rich in reticulo-endo-

placental site, or introducing infection.

The diagnosis from the roentgenogram is dependent upon the recognition of the placental shadow, either in the anteroposterior or lateral roentgenograms, or in some instances in both. This shadow is usually on the ventral side of the fetus and is in continuity with the wall of the uterus. It is not changed by shifting the patient from one side to the other or by the assumption of the erect posture and is definitely not cast by the amniotic fluid. In placenta praevia the extent of shadow which is found in the body of the uterus depends upon the type and degree of placenta praevia. In lateral placenta praevia the shadow is located in the lower portion of the uterine body and disappears behind the shadow of the pelvic girdle. In complete placenta praevia the placental shadow is absent from the upper uterine segment. While it is not usually visible in the lower segment either, because of the concealment by the pelvic bones, yet the high displacement of the presenting part speaks for its presence there. The diagnosis of complete placenta praevia by this method, therefore, is dependent upon the absence of placental shadow from the upper segment of the uterus and displacement of the presenting part from its normal position.

The technique employed in the roentgen studies is as follows:

1. Ordinarily no laxative or purge is given nor even an enema, inasmuch as these measures may create disturbance of the placental attachment. If the roentgenograms taken under these circumstances are not entirely satisfactory, the lower bowel may be emptied by gentle enema, for an accumulation of feces in the rectum and sigmoid may of itself displace the presenting part.

2. Two of the roentgenograms are taken using the technique for bone detail, the first in an anteroposterior position with the patient lying prone on the table and the tube centered midway between the pubis and the umbilicus; the second, in the lateral position with the tube centered over the trochanter of the femur. Then a lateral roentgenogram is made with soft tissue technique, with the tube centered at the lumbar region to reveal the contour of the body and fundus of the uterus. Inspection of these three roentgenograms usually affords sufficient information to make an accurate diagnosis of the position of the placenta, although if special conditions require, additional roentgenograms with soft tissue technique may be taken at other angles. The report that is made from these studies ordinarily includes a decription of the features of pelvic architecture, the relationship of the fetal parts to the pelvis, and the position of the placenta.

At the time I undertook these studies in 1932 I could find in the literature no reference to roentgenological visualization of the placenta without the use of an opaque medium, but upon reviewing the literature of the last few years, I find that there are several investigators who have recorded a similar observation in an occasional case or a limited series. Ude and Urner describe one case in which the shadow of placenta praevia was observed in a roentgenogram without contrast medium, and in 1934 Snow and Powell published a résumé of their observations upon roentgenological visualization of the placenta. They state: "We have been able to demonstrate the placenta in the routine roentgen examination of the abdomen of pregnant women in a very high percentage of cases. In fact, we believe that with a reasonable amount of technical accuracy in making the exposures, no difficulty will be encountered. The placenta was not seen heretofore because we did not look for it." These observers presented a report of some 75 cases in which observations were made, but state that they did not have the opportunity of studying placenta praevia. It is probable that their investigations were going on about the same time as mine and with their viewpoint I am entirely in accord.

SUMMARY

I trust that the facts we have presented here will serve to emphasize the value of this method of study of placental position.

study served to distinguish them as distinctly soft tissue rather than fluid. I then began taking roentgenograms of the fundus of the pregnant uterus with soft tissue technique for the specific purpose of bringing out these details, and found that in practically every instance in which the placenta was located in the body or the fundus of the uterus it could be visualized either in the anteroposterior or the lateral roentgenogram. After some experience and trial of the method I felt sufficiently confident of the findings to make report of the position of this organ in each of the roentgenograms which we made of the pregnant uterus. This phase of the study was started in 1932 and was developed during the subsequent six months. By the latter part of 1933 I began making formal reports of the placental location in addition to the routine description of the size and contour of the pelvis, position of the fetus, proportions between the fetus and maternal pelvis, etc. During the past six years the Department of Roentgenology has submitted to the obstetricians over one thousand reports of placental localization. Judging from the comments of the Obstetrical Department, these reports have been of service in the handling of those complications of pregnancy and labor which have to do with position and attachment of the placenta.

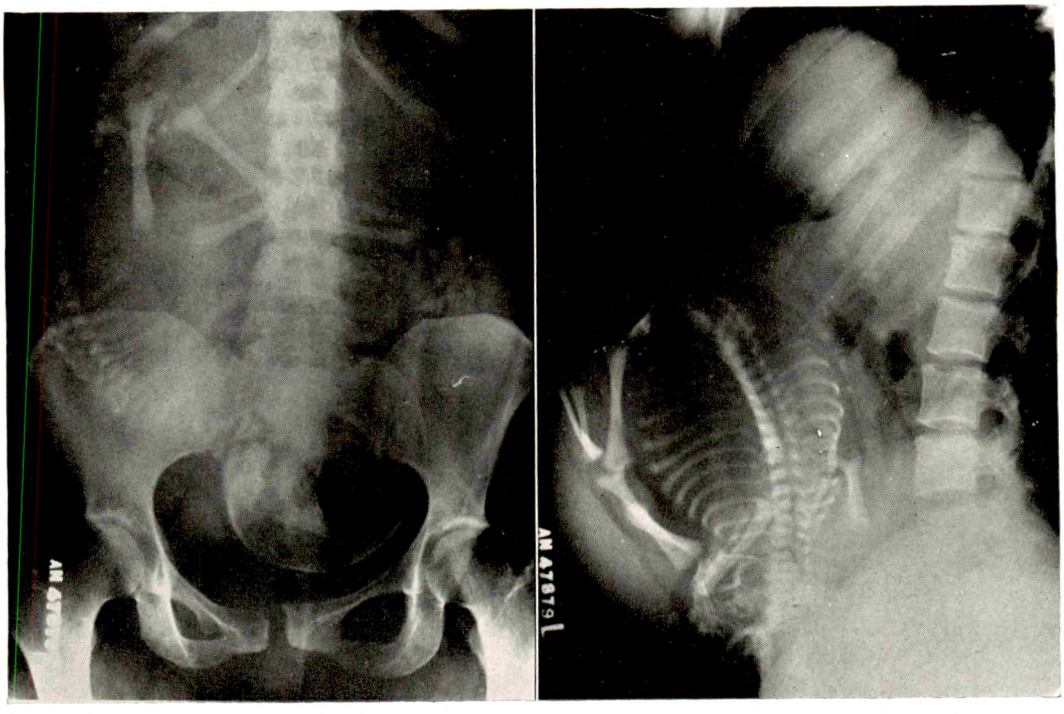


FIG. 2. Left occipitoposterior position of the fetus. Note that the placental shadow is anterior in the lateral view.

My experience with this roentgenologic method leads me to believe that not only is it accurate, but has certain advantages: (1) it ordinarily requires no special preparation of the patient; (2) it makes unnecessary the injection of opaque medium, either into the amniotic cavity or into the bladder; (3) it permits of a determination of the position of the placenta not only in head presentation but also in those abnormal presentations which seem so frequently associated with placenta praevia, that is the breech, the shoulder, the face, the brow, etc., and (4) it permits of the making of a diagnosis without any local manipulation of the pelvis without the possibility of disturbing the

SYPHILITIC SPONDYLITIS*

By EUGENE FREEDMAN, M.D., *and* I. MESCHAN, M.D.
CLEVELAND, OHIO

INTRODUCTION

MUCH has been written about syphilis of the bony skeleton and about Charcot's disease of the spine and other bones and joints, but references to syphilis of the spinal column have been few. This meager literature is partly due to the fact that the diagnosis is difficult to prove, even on histologic examination.

Syphilis of the vertebrae should not be confused with Charcot's spine. Charcot's spine is secondary to changes in the dorsal root ganglia and dorsal columns of the spinal cord associated with loss of sensory perception. This loss in turn impairs the reparative mechanisms of the spine to the traumatic effects of everyday life. Minute fractures occur which are not observable roentgenologically. Hemorrhage ensues with subsequent disintegration of the constantly traumatized bone, with a loosening of the ligamentous structure which is followed by extensive areas of new bone formation. The end-result is a combination of bizarre bone destructive and extensive new bone productive changes.

Syphilitic spondylitis, on the other hand, is elicited by an invasion of the periosteum and bone by *Treponema pallidum*.

HISTORICAL REVIEW

The earliest case report of syphilitic spondylitis was by Monroe[8] in 1772, who published it under the title of "venereal eroding ulcer and venereal caries of the vertebrae of the neck."

Frank,[3] in 1798, reported a case of syphilitic areas involving the third, fourth and fifth lumbar vertebrae.

In 1904, Neumann[10] collected 55 cases of which 36 involved the cervical spine, 6 the dorsal and 7 the lumbosacral spine.

In 1911, Ziesche[19] wrote a comprehensive review on the subject. He compiled 88 cases, 86 of which were from the literature. He found that men were more commonly affected than women, the ratio being 71.4 per cent to 28.6 per cent. The disease was fairly evenly distributed among the various age groups. The regional incidence showed approximately 70 per cent in the cervical region, 13.5 per cent in the dorsal column, and the rest in the lumbar or sacral column, or multiple distribution.

The great majority of the cases of Neumann,[10] Petren[12] and Ziesche[19] were not confirmed by autopsy, the diagnoses having been based mostly on clinical, and, in a few instances, on roentgen findings.

In 1914, Hunt[6] added 4 cases. Three of these showed roentgenologic evidence of the disease, but in the fourth instance no roentgenographic changes were seen and the diagnosis was based on clinical arthritis in a known syphilitic patient which responded to specific therapy. He stated that up to that date the number of reported cases of syphilitic spondylitis was 100.

In 1915, Whitney and Baldwin[17] reviewed the roentgenograms of the spines of 100 consecutive patients with positive blood Wassermann reactions. They diagnosed gummatous lesions of the spine in 3 patients, based on the finding of destructive changes in the vertebrae. They stated that 68 of these patients had clinical symptoms referable to the spine such as localized stiffness and hypotonicity without positive roentgen findings. They concluded that syphilitic spondylitis is more common than suspected, and they stated that all patients who have a positive Wassermann reaction associated with hypotonicity and localized stiffness of the vertebrae should be suspected of having syphilitic spondylitis.

In 1925, Cofield and Little[2] reported upon 111 cases listed as luetic bone and joint disease in the files of Cincinnati General

* From the Department of Roentgenology, University Hospitals, and Western Reserve University School of Medicine, Cleveland.

In summary, let me state that the diagnosis of placental position has been made in over one thousand cases by roentgen examination without the use of contrast medium; that the findings in the instance of placenta praevia have been confirmed by the obstetrician, both in vaginal delivery and cesarean section; that the method has received acceptance in the obstetric clinic and apparently has come to play an important part in the management of certain obstetric difficulties where such knowledge is of importance; that the results have been achieved without disturbance of the patient or without the necessity of the injection of any contrast medium which might endanger the pregnancy or cause inconvenience to the patient, and that while the method requires a certain amount of study, observation, and special interest on the part of the roentgenologist, yet it is in no way beyond the ability of the specialist in this field.

REFERENCES

1. Adair, F. L., and Davis, M. E. Amniography with skiodan injections; preliminary report. *Am. J. Obst. & Gynec.*, 1933, *26*, 881–884.
2. Burke, F. J. Amniography. *J. Obst. & Gynaec. Brit. Emp.*, 1935, *42*, 1096–1106.
3. Campbell, A. M., Miller, J. D., Menees, T. O., and Holly, L. E. Diagnostic value of radiopaque contrast media in gynecology and obstetrics. *Am. J. Obst. & Gynec.*, 1932, *24*, 542–552.
4. Cary, W. H. Note on determination of patency of Fallopian tubes by use of collargol and x-ray shadow. *Am. J. Obst.*, 1914, *69*, 462–464.
5. Cornell, E. L., and Case, J. T. Neoskiodan in amniography. *Am. J. Obst. & Gynec.*, 1934, *27*, 894–896.
6. Friedman, J., and Macdonald, D. O. Roentgen ray diagnosis of placenta praevia. *Canad. M. Ass. J.*, 1935, *32*, 12–14.
7. Hall, S. C., Currin, F. W., and Lynch, J. F. Diagnostic value of the x-ray in placenta praevia. *Am. J. Obst. & Gynec.*, 1937, *33*, 625–631.
8. Heuser, C. Lipiodol in diagnosis of pregnancy. *Brit. J. Radiol.*, 1926, *31*, 110–113.
9. Hundley, J. M., Jr., Walton, H. J., Hibbitts, J. T., Siegel, I. A., and Brack, C. B. Physiologic changes occurring in urinary tract during pregnancy. *Am. J. Obst. & Gynec.*, 1935, *30*, 625–649.
10. McDowell, J. F. Cystographic diagnosis of placenta previa. *Am. J. Obst. & Gynec.*, 1937, *33*, 436–443.
11. McIver, J. Use of the cystogram in diagnosing placenta praevia. *Texas State J. Med.*, 1936, *32*, 471–474.
12. Menees, T. O., Miller, J. D., and Holly, L. E. Amniography; preliminary report. Am. J. Roentgenol. & Rad. Therapy, 1930, *24*, 363–366.
13. Miller, H. A., and Martinez, D. B. Iodinized oil in diagnosis of pregnancy. *Radiology*, 1928, *11*, 191–193.
14. Priest, R. E. X-ray diagnosis of placenta previa in general practice. *Minnesota Med.*, 1937, *20*, 163–167.
15. Rubin, I. C. X-ray diagnosis in gynecology with aid of intra-uterine collargol injection. *Surg., Gynec. & Obst.*, 1915, *20*, 435–443.
16. Rucker, M. P., and Whitehead, L. J. Use of lipiodol in early diagnosis of pregnancy. *J. Michigan M. Soc.*, 1928, *27*, 559–567.
17. Snow, W., and Powell, C. B. Roentgen visualization of the placenta. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 37–40.
18. Steele, H. G. Diagnosis of position of the placenta in utero. *West Virginia Med. J.*, 1937, *33*, 515–519.
19. Ude, W. H., Weum, T. W., and Urner, J. A. Roentgenologic diagnosis of placenta previa. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 230–233.
20. Ude, W. H., and Urner, J. A. Roentgenologic diagnosis of placenta previa. *Am. J. Obst. & Gynec.*, 1935, *29*, 667–679.
21. Wells, W. W. Placenta praevia with discussion of an x-ray aid. *J. Oklahoma M. Ass.*, 1937, *30*, 285–289.

nerves may be involved primarily by the specific inflammation, or secondarily by pressure from the tumefaction.

The discs may be involved by the gummatous process and destroyed by syphilitic granulation tissue. A secondary superimposed infection may likewise be present.

ETIOLOGY

The organism is, of course, the *Treponema pallidum*. As previously indicated, there is a marked predilection for involvement of the cervical vertebrae. The reason for this is not known. In syphilitic osteitis elsewhere it seems that the bones most affected are those exposed to slight trauma and pressure, such as the frontal bone, the sternum, clavicle, radius and tibia. The cervical vertebral column is the most freely movable part of the spine and this may play a part in its relatively greater frequency of involvement.

Secondary invaders and infection may participate in this phenomenon. Hunt believes this is due to an extension from a pharyngeal ulceration, and this is Neumann's contention. Ziesche's patient had an ulcerative area in the pharynx with a fistulous tract extending to the vertebrae, and sequestration. Moreover, congenital syphilitics in whom gummatous involvement of the pharynx is rare do not show the same proportional involvement of the cervical column.

In most of the cases, spondylitis occurs in the malignant form of syphilis where, despite repeated therapy, new phenomena present themselves. The condition may occur in congenital syphilis, or during the second or third stages of acquired syphilis. The disease rarely develops before the secondary skin changes set in. However, Ziesche reports a case of a two year old infant who was infected by his nursemaid and who developed syphilitic spondylitis before the lingual mucous plaques or the plantar pemphigus appeared.

As in other syphilitic osseous lesions, the absence of a history of a primary or secondary syphilis has little importance. Stokes[16] reviewed 239 patients with late luetic osseous and joint lesions and found that 64 per cent gave no history of a primary lesion and 87 per cent denied a secondary eruption. The blood Wassermann reaction was negative in 17 per cent of the cases.

CLINICAL SYMPTOMATOLOGY

The symptomatology is not definite. There is localized pain which may be more marked at night, stiffness, and tenderness to palpation as the result of the periostitis. The normal lordosis of the spinal column is straightened out. The head is held stiff and motions are avoided. According to Hunt, neurological symptoms occur in about 26 per cent of the cases. Compression of the cord is seldom marked enough to produce a compression myelitis. Sequestra may be coughed up in the cervical type of involvement. Coexisting lesions in other bones are common, especially the sternum, clavicle, tibia and radius.

Occasionally sudden death has been described, especially when erosion into an artery has occurred. Dominel, quoted by Ziesche, describes a case in which erosion into a vertebral artery occurred with bleeding into the spinal subarachnoid space. Landrieux, quoted by Ziesche, described a case in which autopsy revealed a fistulous tract into the internal carotid artery.

We have observed 3 patients suffering from syphilitic spondylitis. All of these patients showed involvement of other bones in addition to the vertebrae. Autopsy was performed on 1 of the cases and the diagnosis was substantiated by histologic findings. In the other 2 patients, all the criteria of a clinical syphilitic spondylitis were present (positive Wassermann reaction and response of some of the bone lesions to antisyphilitic therapy).

Case 1. F. S., aged sixty-three, colored male, was admitted to the hospital on September 1, 1937, with a chief complaint of pain and limitation of motion in the right elbow of three weeks' duration. He had had a painful neck of

Hospital over a period of eight years. Nine of these presented roentgen signs interpreted as syphilitic spondylitis. One of these cases was cited as having been examined at autopsy, showing ankylosis of the cervical vertebrae. The rest of them were not proved.

In 1929, Woringer[18] published a monograph on syphilitic Pott's disease. He recognized three forms of the condition: (1) the osteochondritic, (2) the periosteal, and (3) the gummatous type.

According to him, the osteochondritic form occurs primarily in the fetal period and the first two months of life.

The periosteal form begins in the third month of life and persists thereafter. These intrauterine and lesions of early infancy are usually generalized and symmetrical.

The gummatous type produces foci of bone destruction with frequent involvement of the intervertebral disc simulating the appearance of tuberculous spondylitis, hence his term "syphilitic Pott's disease." This lesion is more localized, circumscribed to one of several bones, and occurs in later life.

In 1931, Abernethy,[1] in 1932, Horn,[5] and in 1933, Gill and Frazer[4] each reported a clinical case of syphilitic spondylitis which was diagnosed by roentgenographic changes of the vertebrae and positive Wassermann reaction, all of which responded both roentgenographically and clinically to antiluetic therapy.

The most recently reported autopsied case was that of Péhu and Boucomont[11] in 1933. Their patient, a child aged fifteen months, had involvement of the long bones and the vertebral column. The twelfth thoracic and the first and second lumbar vertebrae presented a moth-eaten appearance, the disc between them being narrowed. There was a gibbus but no paravertebral abscess and complete microscopic studies showed findings which were consistent with the diagnosis of syphilitic spondylitis but not pathognomonic of it.

In 1938, Sprung[15] reviewed the problem of luetic spondylitis and reported a case with clinical and roentgenologic findings but no other proof.

In 1941, Sgalitzer[14] reported 3 patients suffering from syphilitic spondylitis of the cervical column proved by roentgenologic evidence and response to antiluetic therapy.

The above review demonstrates the great scarcity of pathologically verified cases of syphilitic spondylitis.

PATHOLOGY AND PATHOGENESIS

Ziesche believes that the pathologic anatomy of syphilitic spondylitis is the same as for other bones. The disease starts in the periosteum as a periostitis with a deposition of embryonal cells between the periosteum and overlying connective tissue. An inflammatory edema of the connective tissue ensues. In this stage, the disease may heal. If it persists, the embryonal cells become osteoblasts and periosteal new bone production occurs. Osteophytes or exostoses may form. The inflammatory process extends to the underlying bone and new lamellae form which become deposited on the haversian canals. This leads to a condensation of the involved bone, even to the point of eburnation.

The inflammatory process may continue to progress and the haversian canal may become eroded from its inner surface, leading to bone softening. This he calls "osteitis rarificans." It heals with the aid of hyperplasia of the bone.

A still more marked inflammatory osteoperiostitis and osteomyelitis shows a tendency to a different type of productive process, which results in formation of gumma. Eburnation, however, may occur here also.

Bone necrosis may also occur as the result of occlusion of the blood vessels within the thickened walls of the haversian canals. The necrotic bone may sequestrate.

There is little tendency to pus formation, and abscesses are distinctly uncommon although they may occur.

According to Woringer, the ligamentous structure as well as the dura may likewise be infiltrated by gumma. The adjacent

five months' duration with limitation of motion. He had also noticed a swelling in his right supraclavicular fossa for the past five months. He had lost 42 pounds in weight during that time. His first wife had had 2 stillbirths, but otherwise the past history revealed nothing of significance.

On physical examination, his temperature was 38.5° C., pulse 114, respiration 20 and blood pressure 140/88. It appeared as though he had been ill for some time. Both pupils reacted to light and on accommodation and examination of the eyegrounds showed a moderate venous nicking. There was generalized moderate enlargement of all the lymph nodes, most marked in the right supraclavicular fossa. At the costochondral junction on the left side of the tenth rib there was a hard immovable lump which was smooth and non-tender. The reflexes were normal.

The blood Wassermann reaction was four plus and an examination of the spinal fluid showed no cells, a negative Pandy test, a low first zone gum mastic curve, and normal chlorides and sugar. A culture of the abscess of the left sixth rib revealed no growth after five days. A biopsy of a lymph node and of the involved rib was reported as infectious granuloma, probably tuberculosis. The patient continued to run a low grade fever, always fluctuating around 38.0° C., but otherwise was in good physical condition. However, two weeks after admission he collapsed with all the signs and symptoms of a hemiplegia involving the left arm and left leg. His pulse became imperceptible, his respirations slow, and his blood pressure dropped so that no readings could be obtained. Death ensued.



Fig. 1. Case 1. Lateral view of the cervical spine shows syphilitic spondylitis.

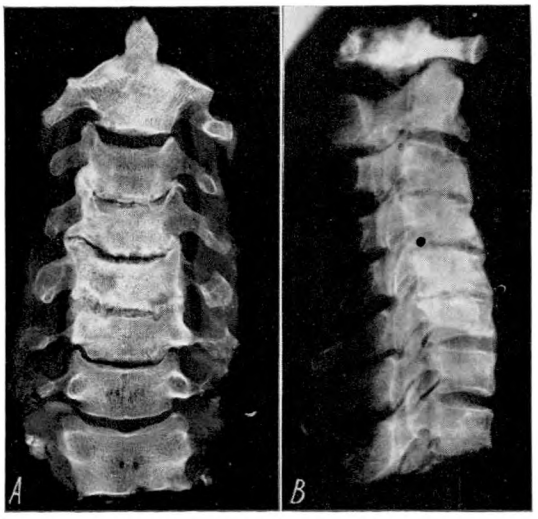


Fig. 2. Case 1. Anteroposterior (*A*) and lateral (*B*) roentgenograms of the cervical spine specimen.

The various roentgen examinations which were obtained were as follows:

A posteroanterior view of the chest showed a dilatation of the aorta indicating the presence of a fusiform aneurysm.

Roentgenograms of the entire length of the right humerus showed periosteal thickening in multiple layers extending upward to about the midportion of the bone.

There was evidence of a slight amount of bone destruction throughout the tenth left rib near the costochondral junction involving an area about 2 cm. in length.

There was an extensive involvement of the third, fourth, fifth, sixth and seventh cervical vertebral bodies with marked irregularity of the contours, narrowing of the intervertebral spaces and overbridging spurs along the borders of the vertebral bodies (Fig. 1 and 2). The third, fourth and fifth lumbar vertebral bodies were also irregular in contour and surrounded by hypertrophic spurs.

These multiple bony lesions were interpreted as being due to a low grade chronic infectious process. In view of the clinical history, these changes were suggestive of syphilitic bone lesions.

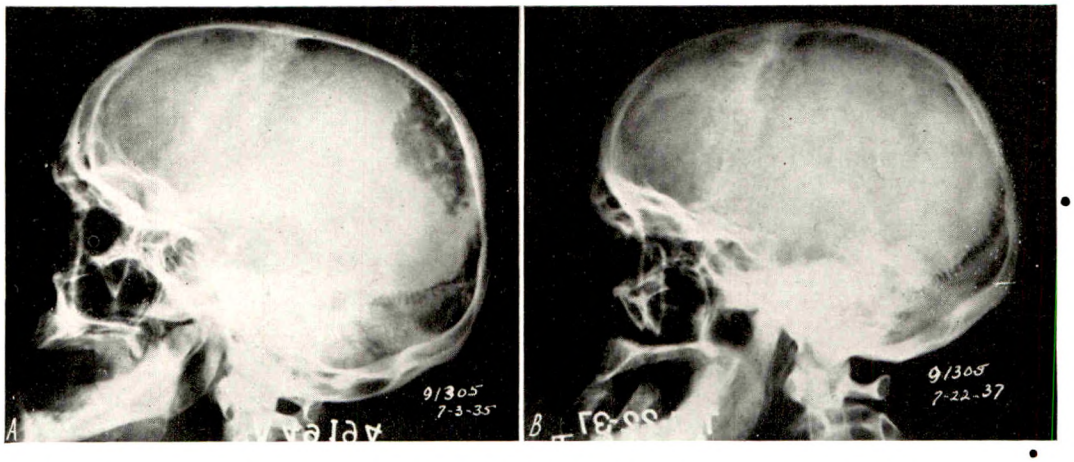


Fig. 3. Case II. Roentgenograms of the skull before (*A*) and after (*B*) specific antiluetic therapy, showing the healing of the gummatous lesion of the parietal region in two years.

At autopsy, the findings were gummas of the liver, gumma of perigastric lymph node, chronic periostitis and osteomyelitis of the sternum, left tenth rib, cervical spine and right humerus, probably syphilitic, syphilitic aortitis, passive hyperemia and edema of the lungs, and other findings which were incidental. Almost complete stenosis of the cerebral vessels was also found. Dr. Howard T. Karsner believed that although no pathologist could make a positive diagnosis of infectious granulomata on the bone lesions, in the light of the clinical findings, the presence of syphilitic aortitis, and of the gummas of the liver, it was justifiable to attribute all of the changes to syphilis.

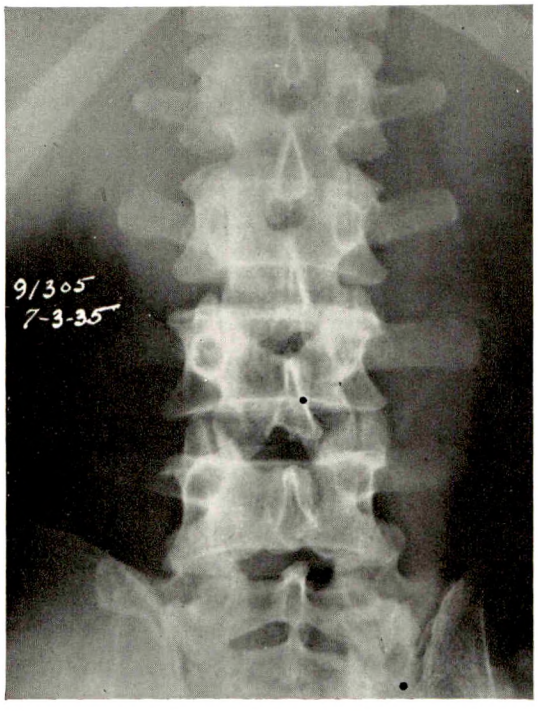


Fig. 4. Case II. Roentgenogram of the lumbar spine obtained at the time the gumma of the skull was first noted. No other roentgenograms of the spine were requested at this time.

Section through the vertebral bodies of the cervical spine shows destruction of the intervertebral discs and gross irregularities of the bone architecture. The cancellous part is dark gray and friable in nature in contradistinction to the normal red bone marow in the normal areas. There is no involvement of this portion of the spinal cord.

Decalcified sections through the cervical vertebrae and the distal end of the right humerus show considerable fibrous proliferation of the periosteum which tissue is old and well formed. There are numerous areas of granulation tissue in the bones and periosteum extending out for a short distance in the soft tissue with marked lymphocytic infiltration of dense granulation tissue. In many areas the bone is replaced by this tissue.

Case II. H. B., male, negro, aged fifty-three, was admitted June 22, 1935, from the Out Patient Department complaining of lumps on the head of two months' duration. For four months he had had severe headaches which had been becoming increasingly worse. He had had a penile lesion and urethral discharge in 1902. He had been hospitalized in Toledo in 1934 where he was given thirteen arm and hip injections for the treatment of "blind staggers."

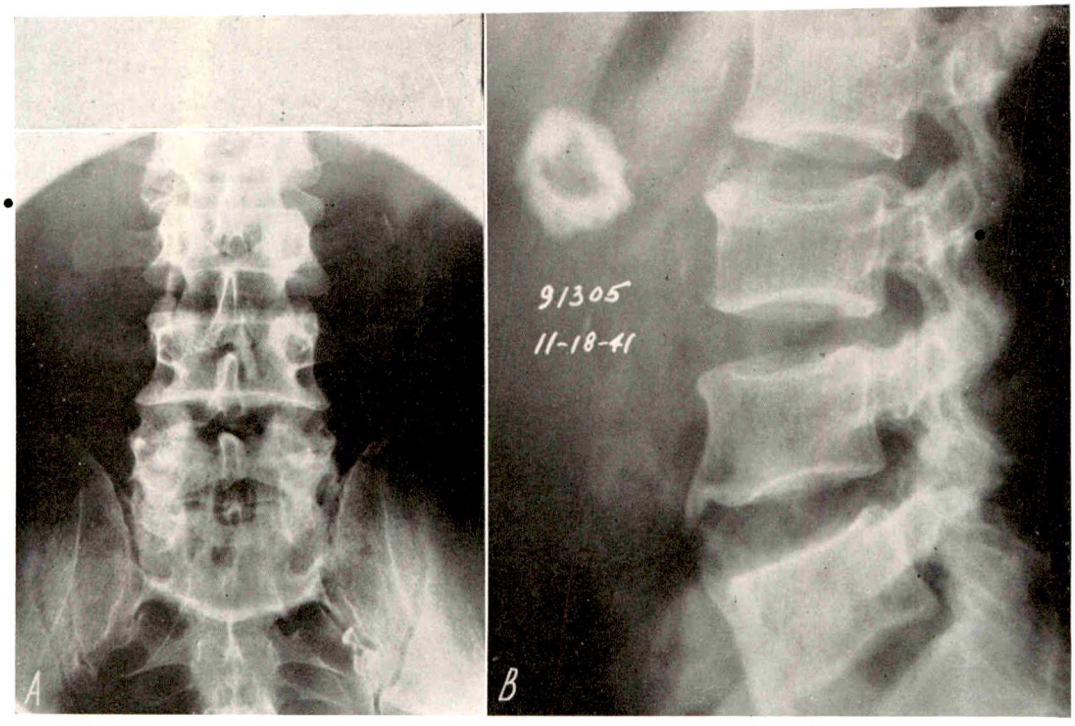


Fig. 5. Case 11. Anteroposterior (*A*) and lateral (*B*) roentgenograms of the spine six years after intermittent antiluetic therapy.

He had been a heavy drinker of alcohol until 1917. Upon physical examination, he was well developed and nourished and not very ill. On the left side of the vertex of his skull there were two small firm masses which were smooth, slightly tender and appeared to be in or part of the bone. There was a diastolic murmur in the aortic area and his blood pressure was 190/80. His blood Wassermann reaction and Kline precipitation tests were four plus. One cubic centimeter of his spinal fluid also had a strong positive Wassermann reaction, with a low first zone gum mastic curve.

The roentgen examinations at the time included the following:

A roentgenogram of the chest showed the heart shadow to be enlarged and the aorta to be diffusely widened. In the cartilaginous end of the first right rib, and in the sixth rib on the left, there were punched-out areas of bone destruction.

Roentgenograms of the skull showed a large moth-eaten area of irregular but generally diminished density in the left parietal bone, measuring 6 by 3.5 cm. The bone changes, mainly those of the skull, suggested a syphilitic osteitis (Fig. 3, *A* and *B*).

Antiluetic therapy consisting of potassium iodide and bismuth was begun on the fourth day and by the twelfth day there was a slight reduction in the size and tenderness of the nodules of the skull. By the twenty-first day he was practically asymptomatic.

Roentgenograms of the skull taken again on July 22, 1937, show that the gumma of the right parietal bone had completely healed, but the lesion in the first rib was increasing in size.

Roentgenograms of the lumbar vertebrae were obtained in 1935 (Fig. 4) and showed no evidence of a pathologic process. No further studies of the spine were obtained until November 18, 1941, and these were at the request of the Department of Roentgenology because of its interest in luetic lesions of the spine. The lateral view of the lumbar vertebrae showed a mottled decrease in density throughout the anterior portion of the fifth lumbar. The posterior portion of the fifth lumbar was sclerotic. There were large bony bridges between the fifth lumbar and first sacral and large spurs between the fourth and fifth lumbar (Fig. 5, *A* and *B*). At this time it was noted that the body of the third cervical was irregular in outline with a rearrangement of the trabeculae of the peripheral portions of the body (Fig. 6). In view of the patient's clinical history of mul-

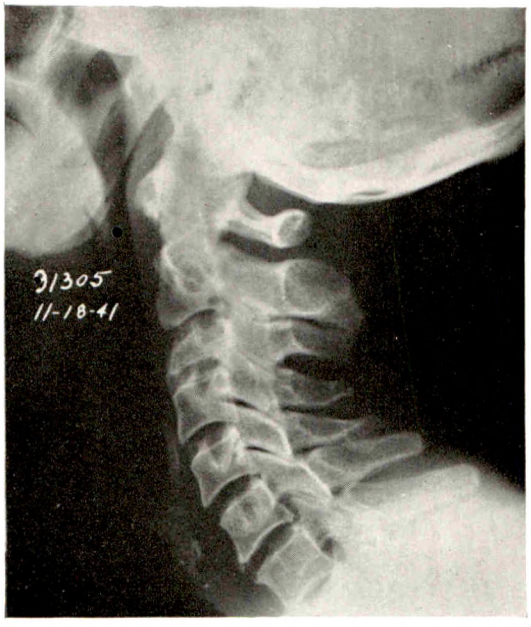


FIG. 6. Case II. Roentgenogram of the cervical spine taken six years after intermittent antiluetic therapy showing involvement of the third cervical vertebra.

CASE III. J. J., male, negro, aged forty-seven, was first seen in the Out Patient Department on October 8, 1934, with a chief complaint of painful neck of one year's duration and stiffness of the neck of six months' duration. He had also had moderate pain in the right knee and right hip for the past year. He denied any venereal contacts and his general health was very good. Upon physical examination it was noted that he could not flex his head and could turn it only slightly. His back was very stiff and he could bend forward only in the lower lumbar region. Lateral flexion was also limited. There were no other significant findings and his reflexes were completely physiological. His pupils reacted to light and on accommodation. A clinical impression of atrophic arthritis of the spine was made and when there was no response to salicylates and physiotherapy, roentgenograms of the cervical spine were made. These showed all the vertebral bodies of the cervical spine to be deformed. The bone trabeculae throughout them were markedly rearranged. There were small areas of diminished density interspersed

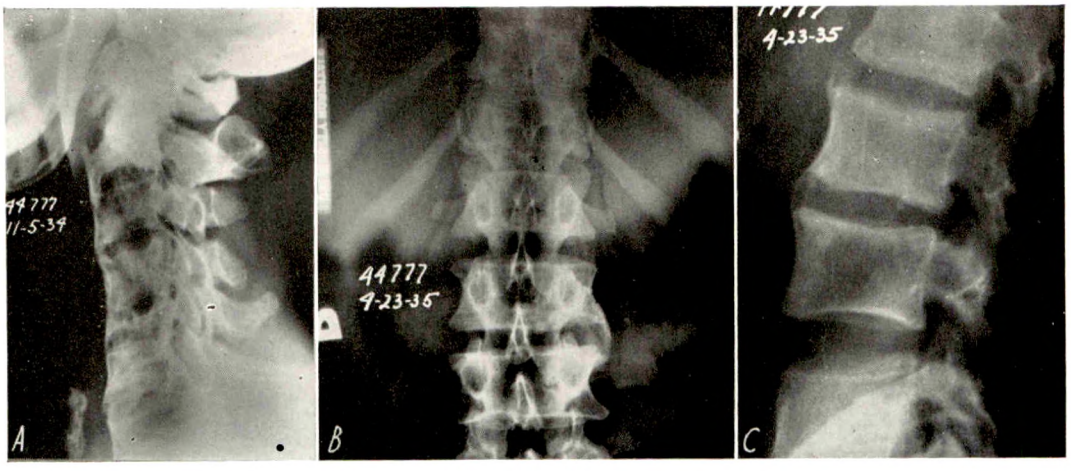


FIG. 7. Case III. Roentgenograms of the cervical (*A*) and lumbar (*B* and *C*) spine before any specific antiluetic therapy.

tiple gummas throughout many portions of the bony skeleton, it was believed that these most likely represented syphilitic osteitis of the vertebrae. They were asymptomatic and were overlooked during their active phase.*

throughout the vertebral bodies and extensive bone destruction in the anterior half of the axis and atlas. The body of the fifth cervical vertebra was markedly collapsed. The anterior portions of the vertebral bodies were overbridged by spurs and ankylosed. Many of the intervertebral discs were narrowed (Fig. 7, *A*, *B* and *C*). The changes were interpreted as indicating a chronic osteomyelitic process, the etiology of which was uncertain. Syphilis,

* Autopsy was performed on February 24, 1943, after this communication was submitted for publication. Histologic examination of the involved ribs and vertebrae "showed dense fibrosis of periosteum and adjacent bone. These changes are not diagnostic of syphilitic involvement, but are entirely consistent with the diagnosis."

tuberculosis, and a nonspecific origin were suggested as possibilities.

A four plus blood Wassermann reaction was subsequently obtained. A course of antiluetic therapy was then instituted, with symptomatic relief. Roentgenograms of the cervical and lumbar vertebrae taken two years later showed an increase in the sclerosis of the involved vertebrae and some reconstruction of the destroyed vertebral bodies. It was concluded that these were most likely syphilitic in etiology, although the most that could be said objectively was that the findings were those of an ankylosing spondylitis (Fig. 8, *A*, *B* and *C*).

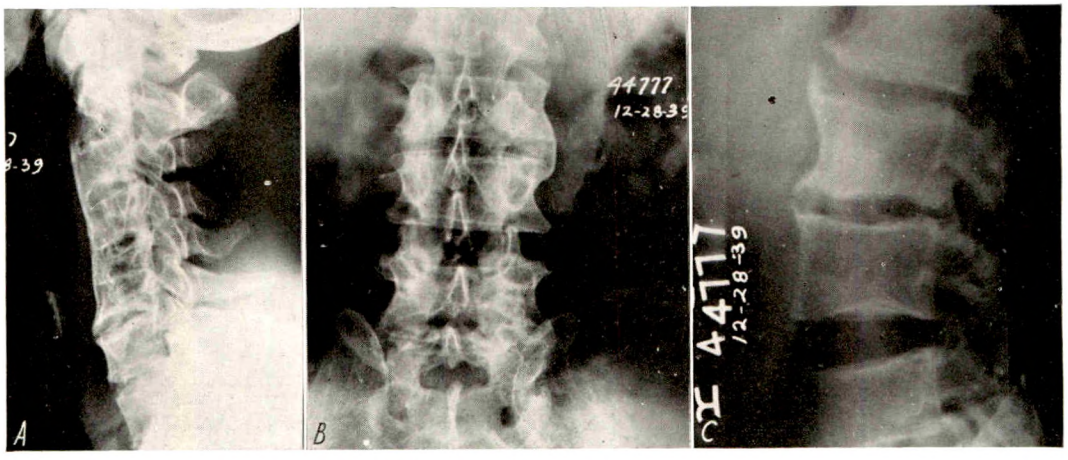


Fig. 8. Case III. Roentgenograms of the cervical (*A*) and lumbar (*B* and *C*) spine after specific antiluetic therapy.

ROENTGEN APPEARANCE

From the various reported proved cases, and from our own, we may conclude that there are certain common characteristics in the roentgen appearance in a certain group of cases which allow the roentgenologist to suggest the presence of a syphilitic spondylitis. Any part of the spinal column may be involved, but there is a predilection for the cervical spine and this is the location where, from the literature and from our own cases, we have found a certain similarity in the appearance of most of the lesions. There is usually evidence of destruction of the vertebral body, especially on its ventral aspect, but there is a marked tendency to osteosclerosis and hyperostosis even to the point of eburnation. There is usually calcification in the anterior and lateral ligaments leading eventually to complete ankylosis. The tendency to eburnation predominates over the tendency to destruction. The intervertebral space may be narrowed or of normal width. This change is in contradistinction to the statement by Sgalitzer who claimed that the intervertebral discs were always well preserved.

The vertebral body may appear somewhat rounded and even larger in size than normal, and the normal bony structure is replaced by either sclerosis or by areas of destruction. Occasionally the two forms are combined. The vertebral end plates may be moth-eaten in appearance or smooth. While in the cervical region the ligaments ossify in a rather uniform and smooth fashion, in the lumbar or dorsal vertebrae large pointed spurs may develop along the anterolateral borders of the end plates. When these changes are present the appearance may simulate a degenerative arthritic process. But while deforming spondylosis is usually a generalized condition involving all or large sections of the vertebrae, the spur formation in syphilitic spondylitis will usually be localized to only two or three vertebrae.

There is usually no paravertebral abscess shadow present although in rare instances it may occur (Horn's case). Sequestration may occur in the cervical column. Subluxation and compression of the vertebral body may occur, especially in the neck.

May, Decourt and Willm reported a case in which syphilitic spondylitis simulated the appearance of hemangioma. The fourth lumbar vertebra had a mottled appearance and its right side was cuneiform in shape. A check examination one year following antisyphilitic therapy showed the vertebrae to be recalcified.

Several reports mention a type of syphilitic arthralgia of the spine (spondylitis syphilitica simplex) characterized by severe pain in the spinal column due to swelling of the small intervertebral articulations. These produce no changes in the roentgenogram. The pain responds slowly to antisyphilitic therapy.

According to the case reported by Woringer, the eburnation or sclerosis may clear up with specific antiluetic therapy. Likewise, Sarrouy and Portier state that the destroyed areas may recalcify with specific therapy.

DIAGNOSIS

The diagnosis is not easy, but will probably be made more frequently if considered in the differential diagnosis of spinal column lesions. To substantiate the diagnosis, the following factors are necessary, which will depend upon a careful history, physical examination, serology, roentgen studies and other laboratory tests.

(1) Existence of active syphilis, either by congenital or determined by marital history, past history or clinical or serological manifestations.

(2) Appearance at an age when tuberculosis of the spine is rare and the absence of tuberculosis elsewhere, although the two diseases may be present simultaneously.

(3) Rapid improvement upon institution of antisyphilitic therapy, although according to Gill and Frazer a round cell sarcoma may also respond to antisyphilitic therapy and it is conceivable that iodides might benefit an actinomycosis also.

(4) The roentgen appearance, although certainly not universally identical, may be strongly suggestive.

(5) The disease has a predilection for the cervical region, although it may occur anywhere in the spinal column.

DIFFERENTIAL DIAGNOSIS

Differential diagnosis must include tuberculosis, nonspecific osteomyelitis, lymphoblastoma, localized metastatic tumor, or primary sarcoma of the spine. The nonspecific osteomyelitides must include those of staphylococcic, streptococcic, typhoid or melitensis origin. Tuberculosis may be differentiated by the fact that it usually begins in the region of the vertebral end plate and the intervertebral disc and leads to early decalcification and partial destruction of the involved vertebra. In the early stages it is a rather rapidly progressive disease. Increased new bone production may occur, but only in the later stages. Paravertebral abscess is usually present in contradistinction to syphilitic spondylitis.

Osteomyelitis from any cause is characterized by an acute onset accompanied by a great deal of pain and systemic reaction. The condition rapidly leads to bone destruction which is soon accompanied by more or less extensive areas of new bone production and rapid regeneration.

Typhoid spondylitis in its early stages is a rapidly advancing disease, but in six to eight weeks after onset it begins to produce spurs surrounding the bone destruction between two adjacent vertebral end plates. These spurs eventually become smooth and overbridge the two vertebrae in a characteristic fashion.

Lymphoblastoma and leukemia produce either bone destructive or new bone productive changes, or a combination of the two, but no spur formations around the vertebral bodies. These conditions are associated with other manifestations else-

where, helping to establish the diagnosis.

Primary sarcoma may be very difficult to differentiate from syphilitic spondylitis. However, coexisting involvement of other bones is rare and the condition usually shows a rapid progression in contradistinction to syphilis.

CONCLUSIONS

Three instances of syphilitic spondylitis are reported. One was verified at autopsy and two by their clinical course.*

The cervical spine is the most commonly involved part of the vertebral column where the lesion usually produces an extensive involvement of the column consisting of a combination of new bone productive and destructive changes associated with spur formations around the vertebral bodies and occasionally calcification of a large portion of the anterior ligament. The intervertebral disc may be intact or narrowed and some of the vertebral bodies may show collapse (Cases I and III).

Occasionally, however, only one cervical vertebral body is involved, as in Case II, where the appearance may cause great diagnostic difficulties unless lesions in other bones also suggestive of syphilis are present.

The involvement throughout the dorsal and lumbar vertebral column yields a less suggestive roentgenological appearance than the diffuse type of cervical involvement.

The disease may be present in only one vertebra or in two or three adjacent vertebrae. These vertebrae may show bone destructive or new bone productive changes, or a combination of the two. Occasionally it may lead to eburnation of the vertebral body. In the majority of instances, the vertebrae become surrounded by more or less marked spur formation imitating the appearance of a nonspecific inflammatory spondylitis.

The diagnosis of cervical syphilitic spondylitis causes no great difficulties, once the physician is conscious of this possibility. The localized cervical, dorsal or lumbar syphilitic spondylitis is more difficult of diagnosis. The etiology can finally be established only by careful clinical studies and by roentgenologic investigation of the entire skeleton which usually shows additional bone involvement.

* See footnote page 762.

REFERENCES

1. Abernethy, C. Two cases of syphilitic spondylitis. *Brit. M. J.*, 1931, *1*, 1112.
2. Cofield, R. B., and Little, C. F. Syphilitic spondylitis. *J. Am. M. Ass.*, 1925, *84*, 174–177.
3. Frank. Pathologie interne. Trad. par Bayles, 1798.
4. Gill, A. W., and Frazer, A. D. Case of syphilitic spondylitis. *Brit. M. J.*, 1933, *2*, 606.
5. Horn. Beitrag zur Diagnose der Spondylitis luetica. *Röntgenpraxis*, 1932, *4*, 31–36.
6. Hunt, J. R. Syphilis of the vertebral column; its symptomatology and neural complications. *Am. J. M. Sc.*, 1914, *148*, 164–179.
7. May, E., Decourt, J., and Willm, A. Syphilis vertébrale avec aspect radiologique pseudo-angiomateux. *Bull. et mém. Soc. méd. d. hôp. de Paris*, 1932, *48*, 1053–1056.
8. Monroe. *Med. Trans.*, London, 1772, *2*, 337.
9. Neumann. Ein Fall von Syphilis der Halswirbelsäule. *Wien. klin. Wchnschr.*, 1903, *16*, 1287.
10. Neumann. Ueber syphilitische Erkrankung der Wirbelsäule. *Wien. med. Presse*, 1904, *45*, 13–20.
11. Péhu, M., and Boucomont, J. Sur un cas de mal de Pott syphilitique chez un enfant de 15 mois: étude radiographique et anatomique. *Rev. franç. de pédiat.*, 1933, *9*, 664–680.
12. Petren, K. Beiträge zur Kenntnis der Syphilis der Wirbelsäule und der Basis cranii. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1909, *21*, 777–806.
13. Sarrouy, C., and Portier. A propos de deux cas de spondylite lombaire syphilitique. *Paris méd.*, 1939, *1*, 362–366.
14. Sgalitzer, M. Roentgenographic diagnosis of vertebral syphilis. *Radiology*, 1941, *37*, 75–78.
15. Sprung, H. B. Spondylitis, Spondylopathie, Spondylolisthesis bei luischer Erkrankung. *Deutsche Ztschr. f. Chir.*, 1938, *249*, 632–650.
16. Stokes, J. H. Modern Clinical Syphilology. W. B. Saunders Co., Philadelphia, 1934, p. 877.
17. Whitney, J. L., and Baldwin, W. J. Syphilis of the spine. *J. Am. M. Ass.*, 1915, *65*, 1989–1994.
18. Woringer, P. Le mal de Pott syphilitique. *Rev. franç. de pédiat.*, 1929, *5*, 446–482.
19. Ziesche, H. Ueber die syphilitische Wirbelentzündung. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1910, *22*, 357–389.

ANGIOCARDIOGRAPHY IN CONGENITAL HEART DISEASE

II. INTRACARDIAC SHUNTS*

By M. F. STEINBERG, M.D., A. GRISHMAN, M.D.,† *and* M. L. SUSSMAN, M.D.
Department of Radiology, The Mount Sinai Hospital
NEW YORK, NEW YORK

THE presence of defects in the cardiac septa as a result of developmental anomalies may result in the mixture of venous and arterial blood currents. The roentgenographic demonstration of these shunts and a more precise definition of associated changes has been made possible by the method of angiocardiography. In 1938 Castellanos, Pereiras and Argelio Garcia[3] successfully demonstrated in several infants a shunt between the right and left ventricles. Following the intravenous injection of 35 per cent perabrodil or uroselectan B a single roentgenogram revealed opacification of the left ventricle at the same time as the right. The application of this method to older children and adults was made possible by the use of a more concentrated halogen compound (diodrast 70 per cent) by Robb and Steinberg[5] in 1938. Recently[6] we described a method for making a series of roentgen exposures during the course of a single injection which permits the right and left phases of the cardiac cycle to be recorded more completely. It is the purpose of this report to illustrate from a group of 65 congenital cardiacs the value of angiocardiography in the study of anatomic features and the physiologic dynamics of intracardiac shunts.

The intracardiac shunts may be divided into the following three types:

I. Interatrial septal defects
II. Interventricular septal defects
III. Transposition of the great vessels.

The last is included because the aorta arises from both ventricles, receiving venous and arterial blood simultaneously, and almost invariably an associated interventricular septal defect is present immediately below the origin of the aorta.

The embryology and pathological anatomy of these anomalies have been described completely by Maude Abbott[1] and need not be repeated. The important physiological principles involved may be summarized as follows:

I. The direction of flow through a shunt depends upon the pressure gradient between the chambers involved.
II. The volume of blood shunted depends, at least in part, upon the size of the communicating defect.
III. The presence or absence of clinical cyanosis depends primarily upon the degree of oxygen unsaturation of the systemic blood (over 6.7 volumes per cent in the presence of cyanosis).

Ordinarily in isolated and uncomplicated septal defects the direction of flow is from left to right. This occurs because the pressure within the chambers of the left side of the heart is considerably higher than that within the right cardiac chambers. However, if for any reason the pressure relationships are reversed, the direction of flow through the shunt is reversed and cyanosis may become manifest. In general, the latter occurs more constantly when the septal defects are associated with other congenital anomalies and especially with those of the pulmonary trunk.

The clinical diagnosis of intracardiac shunts is based upon the history, the localization and transmission of murmurs and bruits, the presence or absence of cyanosis, the roentgen configuration of the heart and

* Grateful acknowledgment is made to the Winthrop Chemical Company for the donation of the diodrast solution 70 per cent which was used in this study.
† Fellow of the Dazian Foundation for Medical Research.

great vessels, circulatory studies and the presence of electrocardiographic changes, especially axis deviation. Recently an objective method for determining the presence of a right to left shunt was described by Benenson and Hitzig.[2] This consists of the intravenous injection of a small amount of ether. In the presence of a venous arterial shunt, if sufficient ether enters the systemic circulation, peculiar paresthesias in the arms, legs and face are experienced by the patient.

We studied 18 instances of intracardiac shunts by means of angiocardiography which were grouped as follows:

Interatrial septal defects	10 cases
Interventricular septal defects	2 cases
Transposition of the great vessels	6 cases
(a) Tetralogy of Fallot (4 cases)	
(b) Eisenmenger's syndrome (2 cases)	

The clinical diagnoses were established on the basis of the criteria given in Table 1. In 2 cases, postmortem confirmation was available.

ANGIOCARDIOGRAPHIC STUDIES

The average normal time sequence of opacification of the cardiac chambers and great vessels is as follows:

Phase	*Structures Visualized*	*Time in Seconds from Beginning of Injection*
I	Superior vena cava, right atrium	0.5–1.5
II	Right atrium, right ventricle, pulmonary arteries	1.5–2.5
III	Right ventricle, pulmonary arteries	2.0–3.5
IV	Branches of pulmonary arteries and veins, left atrium	3.5–4.5
V	Pulmonary veins, left atrium, left ventricle, ascending aorta and aortic arch	4.5–7.0
VI	Left ventricle, entire aorta and branches	5.0–8.5

The discrepancy between these values and the circulation times as obtained by the use of ether, saccharine, decholine, calcium gluconate and sodium cyanide should be noted. An even greater discrepancy has been found in individuals with congestive heart failure and in cases with intracardiac shunts.

Cardiac shunts alter the pattern of angiocardiographic visualization resulting in either premature opacification, persistent opacification or recurrent opacification of the cardiac chambers and great vessels. Each group is considered in detail.

1. *Interatrial Septal Defects.* Uncomplicated cases of this lesion are usually associated with a left to right shunt since the left atrial pressure is normally higher than the right. During auricular systole, therefore, blood flows from left to right through the septal aperture. This increase in volume results in a higher pressure within the right atrium resulting in dilatation and hypertrophy. Any factor tending to augment the venous return may increase the right atrial pressure above that of the left and reverse the direction of the shunt, producing temporary or permanent cyanosis. Exercise, intercurrent pulmonary disorders and heart failure are the clinical conditions which may produce this phenomenon. Rapid intravenous injection of fluid may likewise temporarily reverse the direction of an interatrial shunt. Even a small volume of ether rapidly injected into the antecubetal vein may traverse the septal defect resulting in the characteristic paresthesias which occur when ether enters the systemic circulation. The rapid intravenous injection of 30 to 50 cc. of diodrast 70 per cent might be expected to produce a right to left shunt in the occasional case even though the usual flow is from left to right. That rapid injection may raise the right atrial pressure is suggested by the fact that regurgitation into the inferior vena cava and hepatic veins occurs in some of the anomalies and reopening of the foramen ovale in newborn children following the injection has been demonstrated by Castellanos *et al.* However, these phenomena were not observed in interatrial septal defects.

The expected angiocardiographic pattern in cases of interatrial septal defect with left-right shunt would include revisualization of the right auricle and ventricle after

TABLE I

	History			Physical Examination		
	Attacks of cyanosis	Development	Life span	Murmurs	Thrills	Clubbing
Interatrial Septal Defect	Occasional attacks of cyanosis during infancy. Permanent cyanosis may supervene with onset of heart failure, or severe pulmonary arteriosclerosis	Usually no retardation, either mentally or physically	Normal activity to 4th decade and even longer	Faint to loud systolic over 3–4 intercostal space left of sternum. Murmur has a peculiar high pitch. Occasionally early high pitched diastolic over pulmonary area. Presystolic rare. Murmurs may be entirely absent during childhood	2–4 intercostal space left of sternum	Usually absent
Interventricular Septal Defect	Rare; present only terminally	Frequent retardation, both physical and mental	Usually long	Harsh systolic over 3–4 intercostal space left of sternum transmitted to pulmonary and apical areas. May be absent during infancy and appear later in life	Occasionally present over sternum	Absent
Transposition of Great Vessels	Blue babies, or cyanosis may appear several months after birth	Frequent retardation both physical and mental	Death in infancy or childhood. Occasional cases reach adult life	Systolic over pulmonic area and 3–4 intercostal space left of sternum transmitted to right and down. Early diastolic over aortic area occasionally. Murmur may be absent or negligible in early childhood	Occasionaly over pulmonary area	Marked

the opaque material had reached the left heart. However, the demonstration would probably be difficult because of the already marked dilution of the contrast medium. Actually, demonstration of this type of shunt has not been achieved unequivocally, in our cases although in several a suggestion of persistent right auricular opacification was observed. On the other hand, in at least one case (Case 1) definite opacification of the left auricle was noted almost simultaneously with the right, suggesting that the sudden increase in right auricular pressure temporarily produced a right-left shunt. In one case which was examined at postmortem, the defect in the auricular septum was so large that the auricles appeared as one chamber. It is probable that in this case the structure interpreted roentgenologically to be right auricle actually represented both chambers although an abnormally early visualization of the left ventricle and aorta was not observed. The anatomic features in all of the cases were seen easily. These included:

(a) Marked dilatation of the right atrium, right ventricle, enormous (giant) pulmonary arteries and branches.
(b) Normal left ventricle.
(c) Hypoplastic aorta.

An enlarged left auricle was not seen regularly even in the presence of Lutembacher's syndrome although it was more common when the murmur of mitral stenosis was heard at the apex. Even under these circumstances the right heart remained proportionally larger than the left auricle. It must be remembered, however, that angiocardiography does not provide the precise size of the cardiac chambers if for no other reason than the likelihood that the opaque material does not fully fill the chambers.

II. *Interventricular Septal Defects.* (a) Isolated. In this type of septal defect the

TABLE I

Variants Associated lesions	Complications	Laboratory Data			Conventional Roentgen Findings
		Electrocardiogram	Circulation studies	Venous pulse	
Mitral stenosis (Lutembacher's syndrome)	Subacute bacterial endocarditis rare. Heart failure usually present several years before death	Right axis deviation. High voltage and widening of QRS. Inversion T_2 and T_3. Occasionally no abnormality	Ether test may be positive	Occasionally may be of arterial type	Enlargement of the heart to the left. Enormous dilatation of the pulmonary arterial system. Hilar dance. The esophagus is not displaced posteriorly by a large left auricle but may be by the large pulmonic vessels. Parodoxical systolic expansion of right atrium occasionally. Lutembacher's syndrome—enlargement of the heart to left, large pulmonic arteries, and evidence of left atrial enlargement
Patent ductus arteriosus Aortic stenosis	Subacute bacterial endocarditis common; heart failure uncommon	Usually left axis deviation. Occasionally no abnormality	Ether test usually negative	Normal	Globular heart with predominant left ventricular enlargement
Patent interventricular septum. Stenosis of pulmonary trunk and right ventricular hypertrophy (tetralogy of Fallot). Same but dilated pulmonary trunk (Eisenmenger's syndrome)	Subacute bacterial endocarditis infrequent. Heart failure fairly frequent. Pulmonary tuberculosis common terminally	Right axis deviation. High voltage QRS. Occasionally no abnormality	Ether test usually positive. Arm-to-lung equals arm-to-tongue time	Normal	Coeur en sabot. Peculiar configuration at apex—hump. Cardiac size may not be increased. Inconspicuous pulmonary arteries in tetralogy of Fallot and prominently dilated pulmonary artery in Eisenmenger's syndrome

pressure gradient between the left and right ventricles usually results in a left to right shunt. When the normal relationship between the left and right ventricular pressures is altered due to heart failure, etc., the shunt may be from right to left. This is most unusual and only occurs terminally.

By angiocardiography, in cases of isolated interventricular septal defect, revisualization of the right ventricle after it has emptied is to be expected. This was observed in the single case investigated (Case 11). The shunt will not ordinarily be reversed by the injection because the high pressure gradient between left and right ventricles probably will not be overcome by this means alone. The fact that only a single case was available for study is worthy of note but is compatible with other reported series. For example, Leech[4] discovered 2 interventricular septal defects in 18 congenital cardiacs older than two and one-half years. The lesion has been considered more common probably because differentiation from aortic and subaortic stenosis without the aid of an arterial pulse tracing is difficult.

(b) Complicated (associated with other congenital lesions). An interventricular septal defect occasionally is found associated with another congenital defect of independent embryological origin. In those instances in which the right intraventricular pressure is excessively high due to the presence of an associated stenosis of the pulmonary trunk, superimposed heart failure or pulmonary disease, the direction of flow is from right to left with resultant cyanosis. In such cases the angiocardiographic pattern also follows the right to left shunt, as will be described in the section on tetralogy of Fallot.

Where the associated lesion is on the left side consisting of subaortic or aortic stenosis, the normally existing left to right pressure gradient is increased and in such

instances the angiocardiographic pattern may be expected to show only a left to right shunt. The usual left to right shunt might be reversed by the injection where the associated lesion tends to increase the right intraventricular pressure, partially reducing the pressure gradient between the ventricles.

Not infrequently, the defect is plugged by bacterial vegetations (Case III). This complication will, of necessity, modify the angiocardiographic pattern and correct interpretation becomes impossible.

III. *Transposition of Great Vessels.* Due to embryological arrest of rotation the aorta may arise from the right ventricle entirely or from both ventricles. In the latter, it straddles the outflow of both ventricles and surmounts the interventricular septal defect. Thus, the venous blood passes into the systemic circulation and in effect there results a venous arterial shunt with cyanosis. Complete dextroposition of the aorta with the aorta arising from the right ventricle and the pulmonary artery from the left is imcompatible with long life. Occasionally complete atresia of the pulmonary artery in the presence of an interventricular septal defect may result in a similar but more indirect venous arterial shunt, the venous blood passing from the right ventricle through the septal defect to the left ventricle before it enters the aorta which arises normally.

Transposition of the aorta gives rise to the basic physiological disturbance in several more or less constantly associated cardiac defects which have been described as separate syndromes. The most common is the "tetralogy of Fallot." As originally described this tetrad consists of (*a*) overriding aorta or transposition of the vessels; (*b*) interventricular septal defect; (*c*) pulmonary artery stenosis; and (*d*) right ventricular hypertrophy. The variations of this syndrome are caused mainly by different degrees of aortic rotation. However, variants depend also upon the abnormality in the pulmonic trunk which may be either hypoplastic (atretic), normal or dilated. The dilated pulmonic trunk has been called the Eisenmenger complex.

The essential hemodynamics in all of these related syndromes depends mainly upon the partial flow of blood from the right ventricle into the aorta. The associated interventricular septal defect is secondary from the functional point of view. In this group, angiocardiography reveals simultaneous visualization of the right ventricle, aorta, pulmonic artery and left ventricle within two to three seconds of the beginning of the injection. The pattern is very characteristic because passage of the opaque material directly from right ventricle into the aorta results in unmistakable opacification of the latter; relatively little dilution occurs. In younger children in whom circulation is rapid, even normally, visualization of the entire aorta and the main thoracic arteries within two seconds after injection is the rule (Case IV). The density of the aorta is such that even the abdominal aorta and its main branches are clearly visualized. Since the size of the pulmonic artery is also demonstrated, angiocardiography usually permits precise classification within this group of congenital cardiac anomalies (Case V).

SOURCES OF ERROR IN INTERPRETATION OF ANGIOCARDIOGRAPHIC STUDIES

Errors may occur through technical variations or factors inherent in the dynamics of the individual case. The technical factors result from the injection as for example:

1. *Slow Injection.* If the duration of the injection exceeds two and one-half seconds, right-sided chamber visualization is prolonged and a left to right shunt may be simulated. The simultaneous opacification of both right and left chambers therefore may be found but may be differentiated from a shunt by noting the continuous opacification of the superior vena cava and right atrium throughout the cycle, i.e., at no time does the right side empty.

(2) *Interrupted Injection.* If the injection is interrupted due to mechanical difficulties, a re-opacification of the right chambers is produced which may simulate a shunt, the first phase of the injection having already

opacified the left chambers. The superior vena cava, however, will be noted to be opacified a second time.

(3) *Induced Shunts.* The rapid introduction of fluid may reverse the direction of flow of a left to right shunt. In such instances the usual direction of the shunt should dominate at the end of the cycle and be demonstrable at that time.

The circulatory factors which may occasionally result in misinterpretations or lack of visualization are as follows:

(1) *Rapid Circulation Time.* In young children, febrile illnesses and Graves' disease, the circulation may be so rapid as to result in early visualization of the left chambers even before emptying of the right chambers is complete. Bilateral opacification thus produced may lead to misinterpretation. However, this error can usually be avoided by careful studies of the serial exposures.

(2) *Marked Dilatation of the Cardiac Chambers.* Such dilution of the diodrast may result that opacification beyond the right ventricle is unsatisfactory.

(3) *Associated Valvular Stenoses.* The presence of a marked valvular stenosis may permit only small quantities of the blood-diodrast mixture to enter the chamber beyond the stenosis and result in insufficient opacification of the distal structures.

(4) *Continued opacification of the right chambers* may occur when the opaque material, having passed into the inferior vena cava and hepatic veins, returns to the right heart. Regurgitation into the inferior vena cava during an injection is a common phenomenon in congenital heart disease and in normal children. There is usually no clinical or laboratory evidence of tricuspid insufficiency.

(5) *The presence of vegetations* on the cardiac valves or septal defects may interfere with the passage of the opaque material.

DISCUSSION

The value of angiocardiography in congenital cardiac septal defects depends upon the demonstration of a shunt between right and left sides of the heart as well as the size of the cardiac chambers and great vessels. To demonstrate a shunt, the opaque material must pass through the abnormal channel in sufficient concentration to be distinguishable clearly despite the usual variations in the density and contrast of the roentgenogram which even the most careful technique does not exclude. Hence, the method is of greatest value when a right to left shunt is present more or less constantly, or in other words, in the presence of cyanosis. The absence of cyanosis indicates that the pressure in the left heart is greater than in the right. Therefore, the opaque material will pass into the left heart already diluted before it is shunted back into the right to be diluted more. Occasionally, however, pressure conditions are such that the added volume of opaque material injected rapidly is sufficient temporarily to induce a right to left flow. It is evident, therefore, that angiocardiography occupies a position in diagnosis similar to any other laboratory procedure. Accurate clinical diagnosis is possible in most cases of intracardiac shunts without recourse to the method. However, in the individual case, confirmatory evidence is obtained which may be valuable. Occasionally, for example, interatrial septal defect is mistaken clinically for patent ductus arteriosus. Since the latter is amenable to surgery, any aid in differential diagnosis is important. The value of angiocardiography is only partially impaired when shunts are not demonstrated unequivocally. The fact that cardiac enlargement is due to right rather than left heart dilatation is demonstrated conclusively. These anatomical features are often an indication of the severity of the abnormality and, with the better understanding of the pathological physiology, are likely to be of assistance in determining prognosis.

Angiocardiography is of particular value in the Eisenmenger complex because with conventional roentgenography the large pulmonary artery may obscure the presence of a dextroposed aorta. Fortunately, the simultaneous visualization of aorta and

pulmonary artery soon after injection is quite clear.

The disparity between circulation times and the times when right and left hearts are opacified is difficult to explain. The disparity is particularly marked in the presence of a cardiac shunt. The problem is presumably related to the difference in the concentrations of the various agents required to produce the desired effect.

REPORT OF CASES

CASE 1. *Interatrial Septal Defect; Induced Right to Left Shunt.*

J. S. (No. 484630) (Service of Dr. Eli Moschcowitz). A Negro, aged thirty-five, was admitted to Mt. Sinai Hospital for surgical ligation of patent ductus arteriosus which had been diagnosed clinically at another institution. At two years of age he had lobar pneumonia and acute purulent otitis media which were treated in a hospital. No cardiac abnormality was noted at that time. At the age of ten and twelve he suffered attacks of fever associated with painful swelling of the left knee. At the age of twenty-nine he was operated on for removal of a bullet; at this time he was told of a cardiac condition. Two years previously he began to have symptoms of congestive heart failure. He was hospitalized and in addition to the cardiac lesion, chronic pulmonary tuberculosis was discovered.

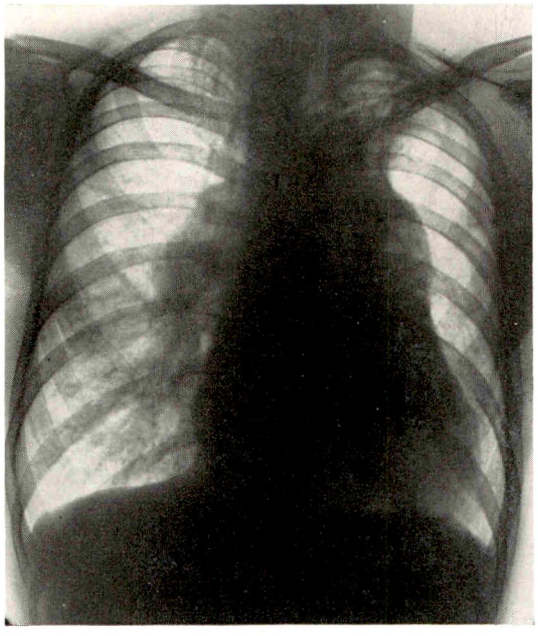
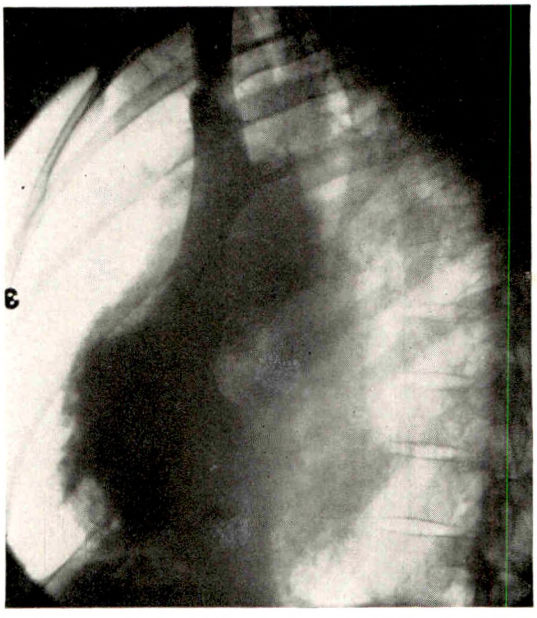


FIG. 1. *Interatrial septal defect.* Case 1. Conventional posteroanterior roentgenogram shows enormous dilatation of pulmonary artery segment of left cardiac contour and associated giant pulmonary artery branches. Heart enlarged both to left and right. Bilateral apical fibroid tuberculosis.

Physical examination revealed a dyspneic colored man. The heart was enlarged at the



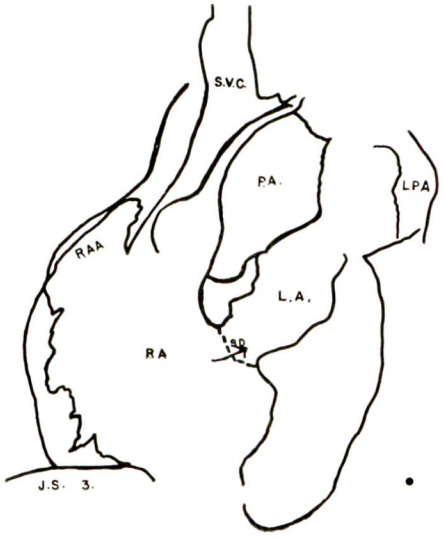


FIG. 2. *Interatrial septal defect.* Case 1. Angiocardiogram taken in left anterior oblique position two and one-half seconds after beginning of injection. A fan-shaped area of opacification is present in the region of the left atrium. Temporary distention of the right atrium produced a right to left shunt.

second left interspace. The point of maximal impulse was felt 1 cm. to the left of the midclavicular line. There was a systolic thrill over the pulmonic area; blowing systolic and diastolic murmurs were heard over the entire precordium, especially marked over the pulmonic area. There was dullness over the left upper lobe; the breath sounds were diminished over this area.

Blood pressure was 116/100. The liver edge was felt three finger breadths below the costal margin.

Laboratory Data. Blood count was within normal limits; hemoglobin, 101 per cent. Urine showed varying amounts of albumin.

Blood serology and chemistry were negative. The electrocardiogram showed right axis deviation; RT_2 and RT_4 depressed; T_2 and T_3 inverted. Phonocardiogram showed a high-pitched systolic murmur over the pulmonic area and an early diastolic murmur over the apex.

Roentgen examination of the chest showed calcific and fibrotic tuberculous infiltration of both upper lobes. The cardiac configuration suggests interauricular septal defect (Fig. 1).

Circulation Studies. Vital capacity 1,500 cc.; venous pulse, 22 cm. of blood; ether, 14 sec. (no peripheral manifestations). Saccharine time, 30 sec.

Angiocardiography showed marked dilatation of the right auricle and ventricle. Almost immediately after the beginning of the injection there was opacification in the region of the left auricle. There was marked dilatation of the main pulmonary artery and its major branches, with a sharp transition in caliber to the secondary branches of the left pulmonary artery, the smaller branches of which were not visualized (Fig. 2), possibly due to thrombosis.

These findings were interpreted as indicating the presence of an interatrial septal defect with an induced right to left shunt.

The patient was successfully treated with digitalis and mercurial diuretics with disappearance of all signs of cardiac failure and he was discharged from the hospital.

Final Discharge Diagnosis: congenital heart disease—patent interatrial septal defect, dilatation of pulmonary artery, possible Lutembacher's syndrome (associated congenital mitral stenosis); possible superimposed rheumatic heart disease, mitral stenosis; congestive heart failure; possible thrombosis of branches of left pulmonary artery; chronic fibroid pulmonary tuberculosis.

Case II. *Isolated Interventricular Septal Defect; Left to Right Shunt.*

N. Y. (No. 474579) (Service of Dr. Bela Schick). A white male child, aged eight, was referred for angiocardiographic studies. He had appeared somewhat underdeveloped physically compared to the other siblings, otherwise he had been in good health. At the age of four years he had lobar pneumonia and at this time the attending physcian noted a cardiac abnormality.

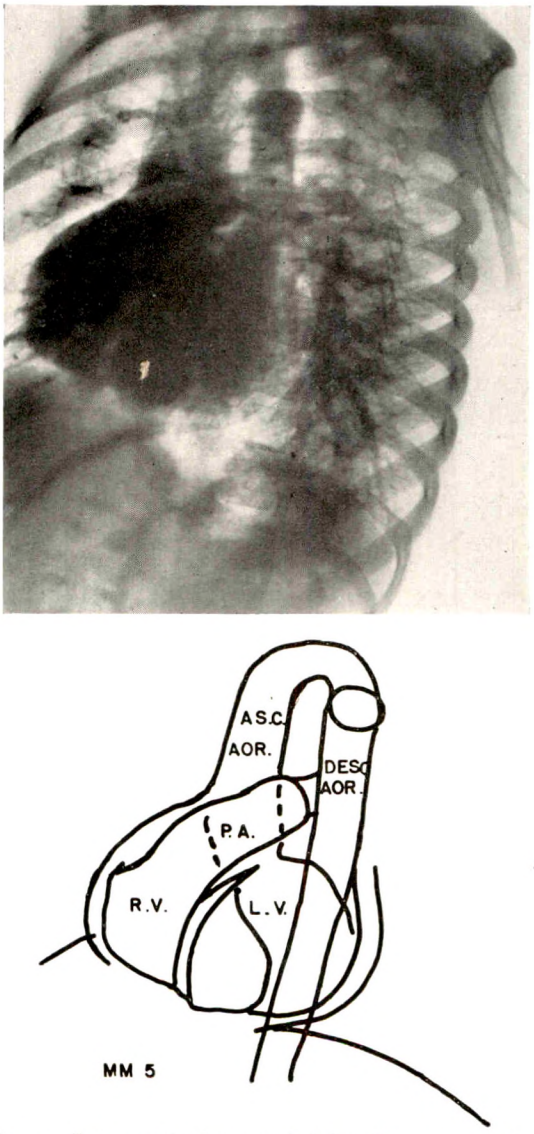
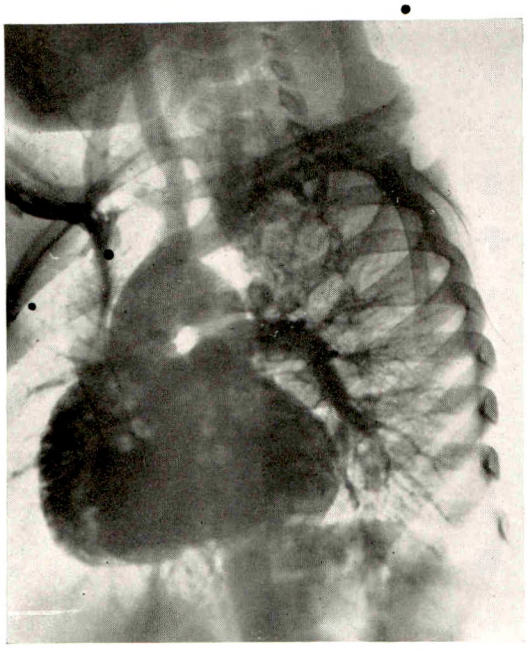


Fig. 3. *Interventricular septal defect.* Case II. Angiocardiogram taken in left anterior oblique position four and one-half seconds after beginning of injection. This shows simultaneous visualization of both ventricles indicating re-opacification of the right ventricle. The latter was seen in previous roentgenogram to have emptied.



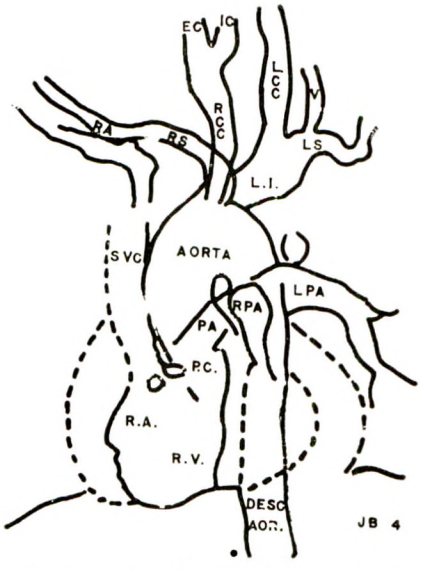


FIG. 4. *Tetralogy of Fallot with right sided aorta.* Case IV. Angiocardiogram taken in left anterior oblique position two seconds after beginning of injection. Complete visualization of entire cardiovascular system indicates transposition of the great vessels as well as an interventricular septal defect. The pulmonary artery is stenotic. In the posteroanterior position the arch and descending aorta were seen to the right of the spine.

Physical examination revealed an underdeveloped but healthy white boy. There was no evidence of cyanosis or clubbing of the digits. The heart was not enlarged to percussion. A loud rough systolic murmur and thrill were present maximally over the mid-sternum.

Blood pressure was 100/70. First degree hypospadias was noted.

Laboratory Data. Hemoblobin 14.5 gm. Urinalysis and blood chemistry, negative. Electrocardiogram showed left axis deviation. QRS of high voltage, suggestive of enlargement of the left ventricle.

Phonocardiogram revealed high-pitched systolic murmur of high amplitude occupying entire systole, best heard at left sternal border between the third and fourth intercostal spaces.

Angiocardiography revealed a re-opacification of the right ventricle four seconds after injection simultaneously with the opacification of the left ventricle. The chambers were moderately dilated. Reflux into the inferior vena cava was noted (Fig. 3).

CASE III. *Complicated Interventricular Septal Defect. Associated Pulmonic Insufficiency due to Congenital Deformed Pulmonic Valve Leaflet. Vegetation of Subacute Bacterial Endocarditis. Occluded Septal Defect, No Shunt Demonstrated.*

E. A. (No. 471053) (Service of Dr. Harold Neuhof). A white male, aged thirty-three, was admitted to Mt. Sinai Hospital for surgical ligation of patent ductus arteriosus. Although he had known of the presence of a cardiac murmur since early childhood, he had led a normal active life until the onset of this illness about nine months previously. At that time he began to have chills, fever, pain in the chest and bloody expectoration. He was hospitalized elsewhere and numerous blood cultures grew many colonies of *Streptococcus viridans*. A diagnosis of patent ductus arteriosus with superimposed subacute bacterial endarteritis had been made.

Physical examination revealed a febrile, dyspneic, emaciated young man. Marked cervical pulsations were present.

The heart was enlarged to the left. A marked systolic and diastolic thrill was felt over the pulmonic area, less distinctly over the apex. The point of maximal impulse was in the sixth intercostal space, slightly beyond the midclavicular line. Over the pulmonary area there was heard a loud blowing low-pitched systolic murmur and a faint high-pitched diastolic murmur (machinery type). The blood pressure was 100/70.

The spleen was felt two finger breadths below the costal margin. Several Osler's nodes were present on the fingers.

Laboratory Data. Blood count revealed a secondary anemia; hemoglobin 60 per cent; leukocyte count 29,400 with 87 per cent polymorphonuclears. Urinalysis showed albumin and red blood cells.

Blood cultures revealed numerous colonies of *Streptococcus viridans.*

Blood urea nitrogen on admission was 9 mg. per 100 cc. and rose to 54 mg. per 100 cc.

Circulation time: saccharine, 15 sec.; venous pulse, 16 cm. of blood.

Electrocardiogram showed left axis deviation, sinus tachycardia.

Phonocardiogram: very prominent high-pitched musical murmurs over entire precordium occupying entire systole and loudest at the pulmonic area. There was present also a fainter late diastolic murmur. A presystolic gallop was demonstrated.

Angiocardiography: right auricle and ventricle are not distinctly abnormal in size. Main pulmonary artery and left pulmonary artery appear dilated. The left ventricle is not sharply outlined. The aorta is of normal caliber but shows a slight dilatation of the descending portion.

Surgical exploration and postmortem inspection of the heart were performed. No ductus arteriosus was found. There was an interventricular septal defect measuring 2 by 2.5 cm. situated in the superior portion of the membranous septum. The aperture was completely occluded by bacterial vegetations. In addition, there was an anomaly of the posterior leaflet of the pulmonic valve resulting in pulmonary insufficiency. Bacterial vegetations were present on the pulmonic and tricuspid valves. The pulmonary artery was markedly dilated. The right ventricle was both hypertrophied and dilated.

Case iv. *Tetralogy of Fallot and Right Aortic Arch.*

J. B. (No. 476580) (Service of Dr. Bela Schick). White female, aged four, who had been cyanotic since birth. Convulsions of jacksonian type had been present since one year of age. Mental development was normal. Dyspnea occurred on exertion with orthopnea. The child became extremely cyanotic on crying.

Physical Examination. Normal size and weight. Lips and mucous membranes were darkly cyanotic. There was marked clubbing of all digits.

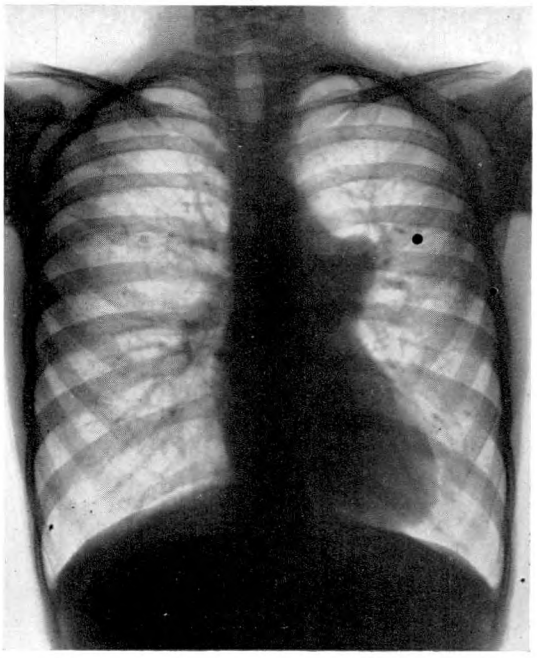


Fig. 5. *Eisenmenger's complex.* Case v. Conventional posteroanterior roentgenogram showing peculiar double contour in the region of the pulmonary artery segment of the heart.

Laboratory Data. Hemoglobin 159 per cent, 22.9 gm. Red blood cells, 12,850,000; leukocytes, 11,800. Blood pressure 108/70. Electrocardiogram: sinus tachycardia; marked right axis deviation; P waves very high; QRS, high voltage; RT 1, 2, 3 depressed; T 3 inverted. The changes suggested enlargement of the right auricle and ventricle.

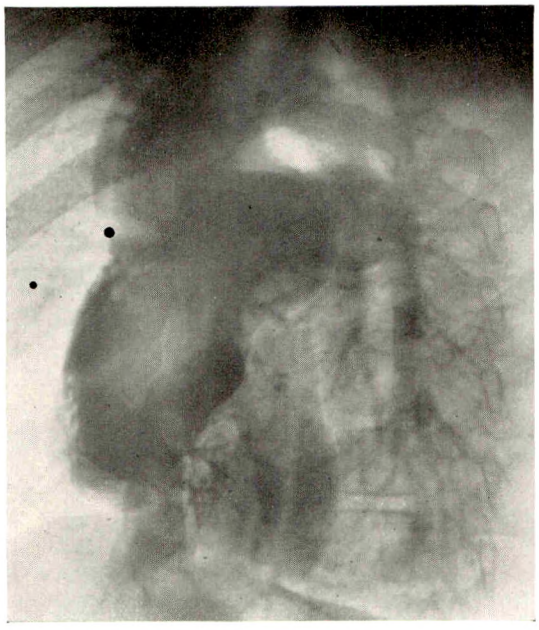
Phonocardiogram revealed very short early systolic murmur of low amplitude over pulmonic area.

Angiocardiography revealed simultaneous opacification of aorta and pulmonary artery two seconds after injection. The right heart was moderately enlarged. The pulmonary artery was small. The aorta was dilated. The arch and descending aorta passed to the right of the spine (Fig. 4).

Case v. *Eisenmenger's Complex.*

B. W. O. (Referred by Cardiac Clinic, Montefiore Hospital, New York City). Male, aged twelve. The patient has been moderately cyanotic since earliest childhood. There were no symptoms of diminished cardiac reserve. Development has been normal.

Physical Examination. Blood pressure 100/



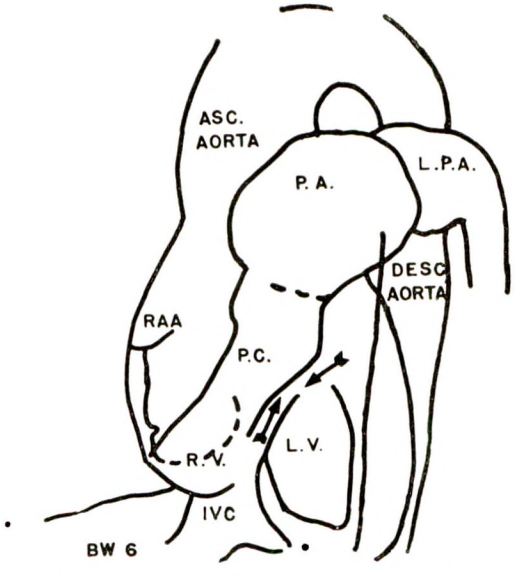


FIG. 6. *Eisenmenger's complex.* Case v. Angiocardiogram taken in left anterior oblique position two and one-half seconds after beginning of injection. Simultaneous opacification of right ventricle, pulmonic artery and aorta indicates that both great vessels arise at least in part from this ventricle. The left ventricle is only partially opacified through the patent interventricular septal defect. The main pulmonary artery and its left branch are markedly dilated.

65. Slight clubbing of all digits. All fingernails were markedly curved (Fig. 5).

Laboratory Data. Electrocardiogram showed regular sinus rhythm. Marked right axis deviation. P waves notched and prominent in leads 2 and 3. QRS of high voltage. These changes suggest enlargement of the right auricle and ventricle.

Phonocardiogram revealed prolonged high pitched systolic murmur of high amplitude present over entire precordium, maximum over the pulmonic area.

Angiocardiogram revealed simultaneous opacification of pulmonary artery and aorta two and one-half seconds after the beginning of injection. The pulmonary artery was markedly dilated (Fig. 6).

CONCLUSIONS

Sixty-five congenital cardiacs have been subjected to angiocardiography. Eighteen cases represented various types of intracardiac shunts. The method usually demonstrated the shunt when a right to left shunt existed and sometimes when it was produced by the injection. In other cases, when the shunt was left to right, re-opacification of the right heart could be made out occasionally. In all cases, the demonstration of the pathological anatomy and physiology present was of value in differential diagnosis. It is likely that with additional data better evaluation of prognosis will be possible.

REFERENCES

1. ABBOTT, MAUDE E. Atlas of Congenital Cardiac Disease. American Heart Association, New York, 1936.
2. BENENSON, W., and HITZIG, W. M. Diagnosis of venous-arterial shunt by ether circulation time method. *Proc. Soc. Exper. Biol. & Med.*, 1938, *38*, 256–258.
3. CASTELLANOS, A., PEREIRAS, R., and ARGELIO GARCIA. La angio-cardiografia en el nino. La propagandista S. A., Habana, 1938.
4. LEECH, C. B. Congenital heart disease; clinical analysis of 75 cases from the Johns Hopkins Hospital. *J. Pediat.*, 1935, *7*, 802–839.
5. ROBB, G. P., and STEINBERG, I. Practical method of visualization of the chambers of the heart, pulmonary circulation, and great vessels in man. *J. Clin. Investigation*, 1938, *17*, 507.
6. SUSSMAN, M. L., STEINBERG, M. F., and GRISHMAN, A. Rapid film changer for use in contrast angiocardiography. *Radiology*, 1942, *38*, 232–233.

Vol. 49, No. 6

MILIARY CALCIFICATION OF THE LUNG*

By ERVING F. GEEVER, M.D., Ph.D.
DENVER, COLORADO

MILIARY calcification of the lung† is fairly frequently encountered by roentgenologists in routine chest surveys and has been the occasion for numerous reports in the past. The condition has been generally considered[1,6,8] to be caused by tuberculosis but several authors have raised the question of other etiological factors. Sutherland[11] believed that it might be related to over-saturation of the blood by calcium salts associated with some metabolic anomaly. Sayers and Meriwether[10] cultured fungi, namely the *Aspergillus*, from the sputum of a number of such cases and felt that the picture could be reproduced by that type of infection. Olson, Wright and Nolan[7] reported results of a Public Health investigation in Ohio and considered the *Ascaris* as a possible cause where tuberculosis could be ruled out. Their study, however, failed to prove or disprove that this parasite was the causative agent. In none of the above reports were pathological studies made. This is understandable since many of the cases were in good health and opportunity for continuous follow up to death and autopsy examination was not available.

The purpose of this report is to present the results of pathological and bacteriological studies in two typical examples of this condition. Both patients died of entirely unrelated diseases and complete autopsy examinations were performed.

Case 1. W. S., male, aged seventy-six, was admitted to Colorado General Hospital on October 30, 1941, complaining of weakness, diarrhea, numbness and tingling of the hands and feet and a loss of 15 pounds in weight, all taking place during the past three months. He stated that he had been under treatment for pernicious anemia periodically during the previous ten years. He had been admitted to this institution on two other occasions, 1937 and 1940, for treatment of that condition. The physical examination on admission at this time revealed old varicose ulcers, external hemorrhoids and bilateral indirect inguinal herniae.

The laboratory studies showed: *urinalysis*: 2+ pus cells; *blood*: erythrocytes 4,510,000, hemoglobin 14.0 grams; *blood chemistry*: nonprotein nitrogen 49, urea nitrogen 25 and creatinine 1.7 mg. per 100 cc.

Roentgen examination of the chest demonstrated miliary calcified lesions distributed evenly in both lung fields. They varied in size from 1 to 3 mm. in diameter. The hilar nodes showed bilateral extensive calcification (Fig. 1).

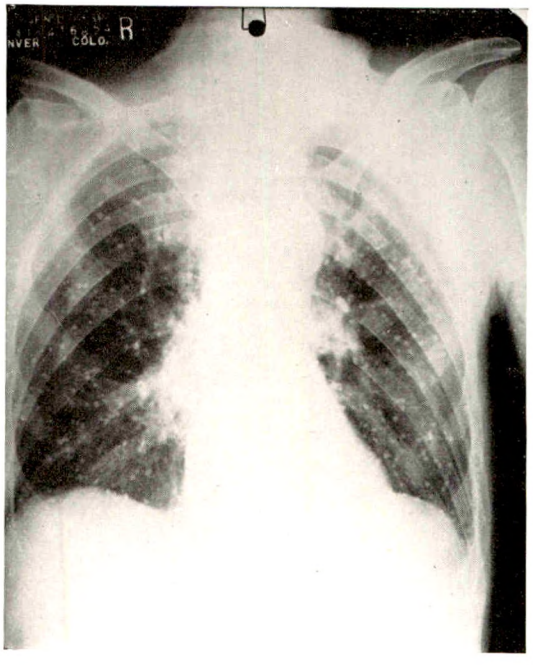


Fig. 1. Case 1. Showing miliary calcified lesions distributed evenly in both lung fields. The hilar nodes display extensive calcification.

Clinical Course. Shortly after admission the patient developed fever which fluctuated between 101.2° and 103.4° F. His course was rapidly retrogressive. Tuberculin skin testing with 0.1 cc. of 1:100,000 O.T. was performed and found to be negative. Death occurred before a subsequent examination with a higher con-

† Also called "miliary calcicosis," "miliary calcinosis" and "wheatena." The latter term has arisen because of the fairly high incidence among workers in wheat fields.

* From the Department of Pathology, University of Colorado, School of Medicine and Hospitals.

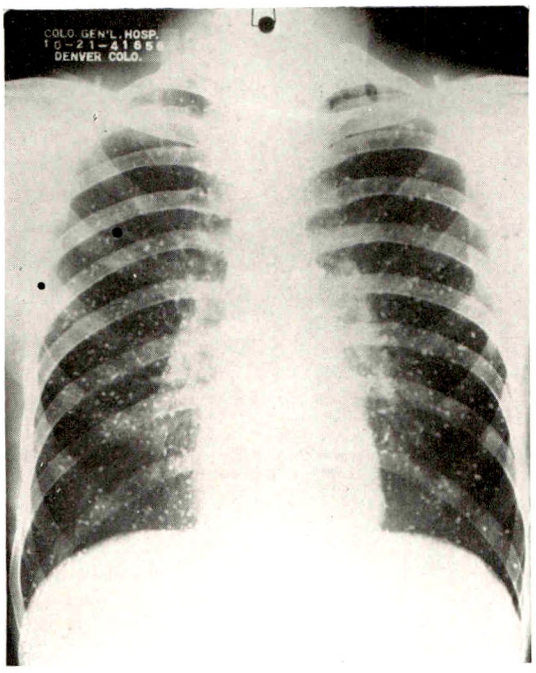


FIG. 2. Case II. Miliary lung calcifications varying from 1.0 to 3.0 mm. in diameter. Hilar nodes are extensively calcified.

centration of O.T. could be carried out. The patient died on November 3, 1941.

Autopsy was performed two hours postmortem and revealed the following significant findings: (1) hypostatic terminal pneumonia, bilateral, moderate; (2) ulcerative ileitis, subacute, moderate, cause undetermined; (3) prostatic hypertrophy, obstructing, moderate; (4) cystitis, subacute, with multiple diverticula, secondary to (3); (5) nephrosclerosis, senile, arterial type, moderate; (6) multiple miliary lung calcifications, bilateral, with secondary bilateral hilar lymphadenitis. The pathological lung findings will be described in detail later.

CASE II. D. M., male, aged thirty-six, was admitted to Colorado General Hospital on January 6, 1941, complaining of shortness of breath and weakness during the past six months, and swelling of the lower extremities for two weeks. He had lost 13 pounds in weight during the latter period. The significant physical findings were ascites, enlargement of the spleen and moderate emaciation.

The laboratory studies revealed: *blood*: erythrocytes 1,100,000, leukocytes 134,400; the differential count showed 35 per cent mature polymorphonuclears, 52 per cent immature myeloid forms, 8 per cent lymphocytes, 3 per cent eosinophiles and 2 per cent basophiles.

Roentgen examination of the chest was performed and demonstrated findings similar to those in Case I. Numerous calcifications varying from 1 to 3 mm. in diameter were distributed evenly over both lungs. The hilar region bilaterally showed extensive calcification (see Fig. 2). The sputum was found to be negative for tubercle bacilli on smear examination and after guinea pig inoculation. Sputum culture on Sabouraud's medium for fungi was also unsuccessful.

Clinical Course. A diagnosis of myelogenous leukemia was made and the patient given several courses of roentgen therapy. Response was satisfactory and he was discharged shortly thereafter. He was readmitted on October 20, 1941, complaining of a return of all the old symptoms, i.e., weakness, shortness of breath and swelling of the legs. Tuberculin skin testing was carried out at this time with 0.1 cc. of 1:100,000 O.T. The test was negative and was repeated later with 0.1 cc. of 1:10 O.T. The latter examination was also negative. Blood study on admission revealed erythrocytes 2,850,000 and leukocytes 114,250. His course was steadily retrogressive and death occurred on November 14, 1941.

Autopsy was performed nine hours postmortem and presented the following positive findings: (1) myelogenous leukemia with hepatomegaly (2,840 grams), splenomegaly (1,550 grams) and myeloid hyperplasia of the bone marrow; (2) chronic organizing pneumonia, severe, bilateral, upper lobes; (3) leukemic in-

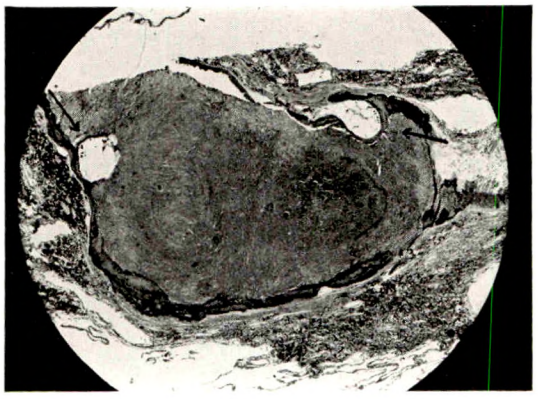


FIG. 3. Case I. Low power (magnification 32×) section of a lesion showing almost complete encapsulation by bone with several marrow foci as indicated.

filtration into the lungs, spleen, liver and adrenals; (4) multiple miliary lung calcifications, bilateral, with secondary bilateral hilar lymphadenitis.

The Pulmonary Lesions

CASES I AND II

The changes in both cases were identical and will be described jointly. Both lungs were



Fig. 4. Case I. Another lesion (magnification 145 ×) demonstrating rhythmic banding, similar to Liesegang's rings, in the central caseous and calcified area; also some marginal ossification.

seeded with many small, hard lesions which were apparent only as they approximated the visceral pleura. In the cut section palpation provided a more accurate impression of their size and character than did visualization. The nodules varied in size from 1.0 to 3.0 mm. in diameter. They were stony hard in consistency and could not be sectioned with a knife; crushing with bone forceps revealed a dry, yellowish-white, amorphous composition. The tracheobronchial lymph nodes, bilaterally, were moderately enlarged and matted together. They were extensively involved by stony hard, yellowish-white infiltrations. The liver and spleen in both patients were not similarly affected.

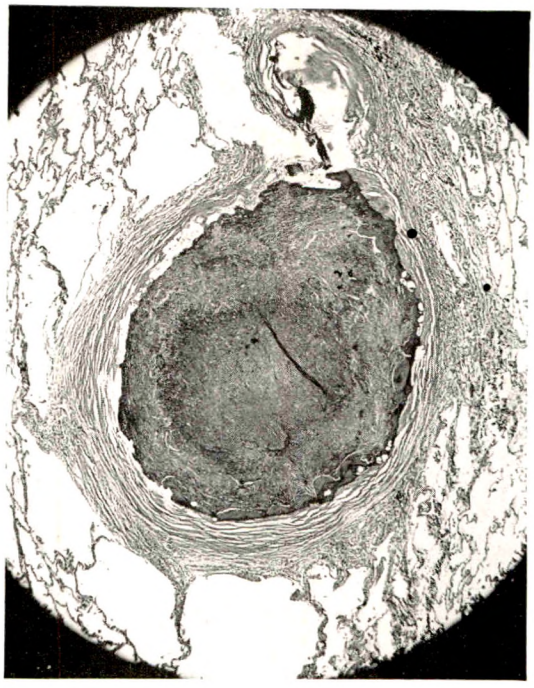


Fig. 5. Case II. Low power (magnification 32 ×) section of a lesion showing approximately two-thirds encapsulation by bone. Central caseation and calcification are demonstrated also.

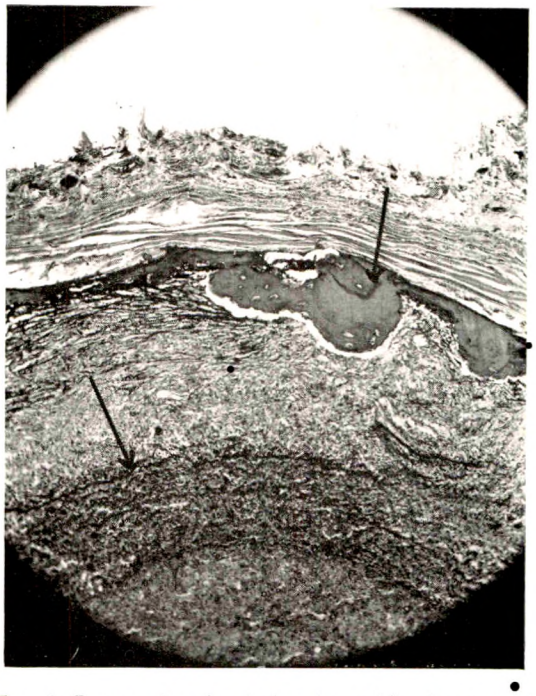


Fig. 6. Case II. Another lesion (magnification 145 ×) with rhythmic banding and a bony margin as indicated.

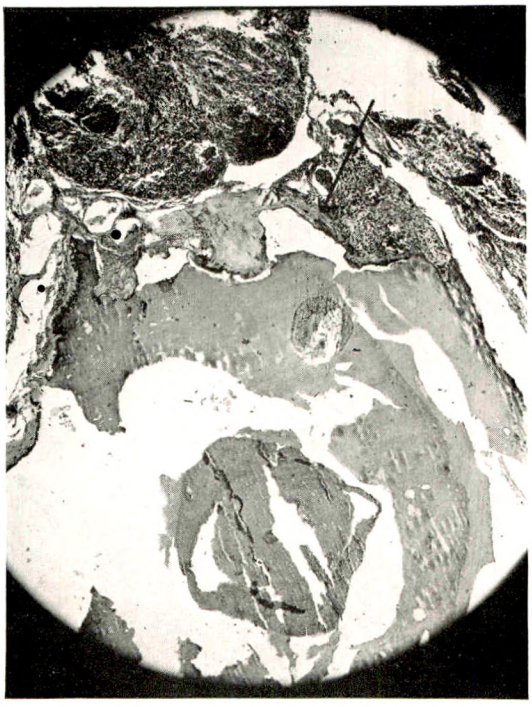


Fig. 7. Case I. Low power (magnification 32 ×) section of hilar lymph node demonstrating central caseation and calcification. Marginal fibrosis is indicated.

Bacteriological Examination. Individual lung lesions as well as specimens of hilar lymph node were removed aseptically and ground up under sterile conditions in a mortar. Digestion was then carried out with weak alkalies, and the sediment stained and examined for tubercle bacilli. Furthermore, the neutralized sediment was injected into a guinea pig. In Case II, additional culture on Sabouraud's medium was undertaken for fungi. The bacteriological studies and autopsy examinations of the inoculated guinea pigs were negative.

Microscopic Pathological Studies. Large sections of both lungs were preserved in Lundquist's solution* and after thorough fixation the individual lesions were isolated and decalcified with mineral acid (5 per cent HNO_3). Each nodule was then carefully sectioned as close to the center as possible and embedded in paraffin. Staining was then carried out with hematoxylin and eosin and carbol-fuchsin. Photomicrographs of the lung sections are provided at different magnifications in Figures 3 to 6. Ten lesions were prepared in the above manner from each case. They exhibited central caseation and varying degrees of calcification, sometimes in concentric layers.* In the periphery, almost every nodule (7 out of 10 in Case I, and 8 out of 10 in Case II) showed ossification of its fibrous capsule. In some instances bone marrow and hematopoiesis could be distinguished. There was no marginal inflammatory reaction although a few epithelioid cells, lymphocytes and plasma cells were occasionally observed. All lesions appeared completely healed. No organisms, i.e., fungi or acid fast bacilli, were noted in either the hematoxylin and eosin or carbol-fuchsin stained sections. The hilar lymph nodes in both cases



Fig. 8. Case II. Low power (magnification 32 ×) section of hilar lymph node showing same features as Figure 7.

* Lundquist's Solution I

For 12 hours or longer dependent on size of section	potass. acetate	35.0 gm.
	potass. nitrate	45.0 gm.
	chloral hydrate	80.0 gm.
	formaldehyde	444.0 cc.
	water	4000.0 cc.

Lundquist's Solution II

For indefinite storage	potass. acetate	10.0 gm.
	chloral hydrate	5.0 gm.
	glycerin	10.0 cc.
	hot water	90.0 cc.

* Dr. James J. Waring has called my attention to the resemblance of this concentric layering to Liesegang's phenomenon.

Bacteriological

(1) Sputum studies
  (a) Culture for tubercle bacilli.
  (b) Culture for fungi.
  (c) Guinea pig inoculation.

(2) Autopsy lesions
  (a) Culture for tubercle bacilli.
  (b) Culture for fungi.
  (c) Guinea pig inoculation.

Pathological

(1) Gross morphology including examination of the regional lymph nodes.

(2) Microscopic study.

Roentgenological examination—periodic chest roentgenograms to establish or rule out progression of the lesions.

CONCLUSIONS

1. Two cases of miliary calcification, discovered incidentally in routine chest (roentgen-ray) examinations, were studied clinically, bacteriologically and pathologically.

2. The complete study suggested the cause for the appearance in the two cases to have been tuberculosis, probably of the primary type.

3. The infection had occurred many years previously, probably in infancy or childhood, and had completely healed. The condition in no way contributed to death in either case.

4. Although the possibility exists that other agents may cause this interesting lung picture, the importance of tuberculosis should not be minimized.

The author wishes to express his appreciation to Dr. James J. Waring and Mr. Donald E. Cummings for their cooperation and suggestions in this study.

REFERENCES

1. BLAINE, E. S. Roentgenological evidence of apparently healed miliary tuberculosis of the lungs. AM. J. ROENTGENOL. & RAD. THERAPY, 1924, *11*, 233–237.
2. BOYD, W. Pathology of Internal Diseases. Third edition. Lea & Febiger, Philadelphia, 1940, p. 191.
3. CRONKITE, A. E., and LACK, A. R. Primary pulmonary coccidioidomycosis. *J. Exper. Med.*, 1940, *72*, 167–174.
4. FELDMAN, W. H., and BAGGENSTOSS, A. H. Residual infectivity of primary complex of tuberculosis. *Am. J. Path.*, 1938, *14*, 473–490.
5. MAVER, M. E., and WELLS, H. G. Studies on the biochemistry and chemotherapy of tuberculosis. XXIII. The chemical composition of so called tuberculous lesions. *Am. Rev. Tuberc.*, 1922–1923, *6*, 649–658.
6. MAYORAL, A. Multiple miliary calcifications in the lung. *Radiology*, 1941, *36*, 367–371.
7. OLSON, B. J., WRIGHT, W. H., and NOLAN, M. O. Limestone formations in the lungs and tuberculosis. *Science* (suppl.), 1941, *94*, 12.
8. OPIE, E. L. The diagnosis of healed miliary tuberculosis. (Editorial.) AM. J. ROENTGENOL. & RAD. THERAPY, 1924, *11*, 289–291.
9. PUHL, H. Ueber phthisische Primar- und Reinfektion in der Lunge. *Beitr. z. Klin. d. Tuberc.*, 1922, *52*, 116–165.
10. SAYERS, R. R., and MERIWETHER, F. V. Miliary lung disease due to unknown cause. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *27*, 337–351.
11. SUTHERLAND, C. G. Miliary calcification in the lung. *Med. Clin. North America*, 1925, *8*, 1273–1286.
12. SWEANY, H. C. Recent studies bearing on tuberculous infection and reinfection. *Acta tuberc. Scandinav.*, 1939, *13*, 67–102.
13. SWEANY, H. C. Pathology of primary tuberculous infection in the adult. *Am. Rev. Tuberc.*, 1939, *39*, 236–255.
14. TERPLAN, K. Anatomical studies on human tuberculosis. *Am. Rev. Tuberc.* (suppl.), 1940, *42*, 1–176.

also presented similar changes which differed only in the absence of peripheral ossification (Fig. 7 and 8).

DISCUSSION

The possibility that diseases other than tuberculosis may cause miliary lesions in the lungs cannot be denied. Some of the etiological factors suggested on the basis of studies in humans have already been referred to. Experimentally, Cronkite and Lack[3] reproduced the picture to some extent in guinea pigs by having the animals inhale dry mycelial spores of *Coccidioides immitis*. The early lesions were translucent, grayish nodules up to 2 mm. in diameter and proved to be granulomata microscopically. Epithelioid cells, occasional multinucleated giant cells and several typical spherules of coccidioides could be distinguished in such granulomata. In the 2 cases presented here the most likely diagnosis, in my opinion, appeared to be healed miliary tuberculosis of the primary type. This interpretation was made on the basis of the close resemblance of the lesions to healed Ghon tubercles and because of the extensive regional (hilar) lymph node involvement. The negative tuberculin tests and bacteriological studies were not considered to be decisive objections to this diagnosis. The question of tuberculo-allergy becoming spontaneously extinguished in healed tuberculosis is controversial. However, it can be stated as fairly well accepted that the sensitivity may be depressed in patients in a cachectic state whether the latter is due to tuberculosis or other diseases. In such cases a tuberculous focus could exist with a negative tuberculin reaction. The test was performed two days before death in Case I, in Case II ten days before death. The absence of bacteriological verification is also not unusual in old healed tuberculous lesions. Feldman and Baggenstoss,[4] for example, found viable organisms in only 1 case out of 68 subjects in whom the lesions of the primary complex were examined for tubercle bacilli.

Bone formation in tuberculous foci is of particular interest and is frequently observed in primary tuberculous lesions found in routine autopsy examinations. Boyd[2] considered ossification in lung or lymph node lesions as an indication of a primary tuberculous infection. Terplan[14] found that 60 per cent of all primary foci in his adult series contained bone. Puhl[9] also stressed bone formation as very frequent in healed primary lesions (50 per cent in his group). Although the latter author admitted that reinfection lesions might run through the same sequence of changes, bone formation was only rarely observed. Sweany,[12] on the other hand, interpreted the presence of bone as an indication merely of extreme age of a tuberculous lesion and stated that ossified foci are at least ten years old. Sweany[13] also pointed out that "There is no absolute way of telling a primary lesion by pathological appearances alone." The presence of bone in a tuberculous focus is probably not specific for a primary infection, although it is commonly found in such lesions. In the 2 cases described, however, the combination of ossified foci and extensive regional (hilar) lymph node involvement would appear to justify an interpretation of a primary type of infection. The latter had undoubtedly taken place a long time ago, probably in infancy or childhood, and had resolved in complete healing. In no respect had the condition contributed to the fatal issue in either patient.

For future clarification of this problem it is recommended that the following studies* be performed whenever an opportunity presents itself to examine a patient who demonstrates this finding in a chest roentgenogram.

Clinical

(1) History of contact with tuberculosis.
(2) History of pulmonary tuberculosis.
(3) Determination of tuberculo-allergy by tuberculin skin testing.

* The value of chemical analysis is doubtful as pathologically calcified tissue has approximately the same composition whether produced in tuberculosis or in the course of other diseases (Maver and Wells[5]).

VOL. 49, NO. 6

LAYER FORMATION IN PYELOGRAPHY

By ALICE ETTINGER

From the Department of Radiology of the Boston Dispensary and Pratt Diagnostic Hospital
BOSTON, MASSACHUSETTS

PYELOGRAPHY in general has not as yet developed to such a degree of perfection that its results have the same degree of diagnostic reliability as the results in other fields of roentgenology. One needs only to glance over the pages of one Quarterly Cumulative Index Medicus to find that every year several articles are published with the title "Pitfalls in Urography."

We have to ask ourselves whether these pitfalls are due to inherent limitations of the method employed, or whether by technical improvements or better knowledge of interpretation these pitfalls can be diminished. Well known is the fact that a normal pyelogram may be obtained in the presence of a malignant tumor.[22] If a tumor starting in the cortex of the kidney has not yet deformed the renal pelvis, we will be unable to demonstrate it by pyelography. It is immediately obvious that we are facing here an inherent limitation of the method. We should not be more disappointed about this diagnostic failure than we are about our inability to demonstrate tumors in other parenchymatous organs. There are, however, other failures of diagnostic accuracy in pyelography which we believe can be avoided by a more careful technique and interpretation.

In this paper we shall try to demonstrate one possible source of error in interpreting pyelograms and a method of avoiding such errors. First, a word may be said in regard to the merits and the diagnostic value of the retrograde and intravenous methods. A great many papers[6,23,24] have been published evaluating the indications for either method and the results obtained. There is a surprising lack of unity of opinion in regard to this subject, as one can readily see by statistics published by Cumming and Chittenden.[5]

It has been claimed that intravenous pyelography frequently does not give as exact anatomical detail as retrograde pyelography. We feel that by recent technical improvements in intravenous pyelography, mainly the use of compression, the method has been improved to such an extent that this claim is no longer valid.

There have been numerous papers published in recent years about compression technique. Compression was recommended many years ago by Ziegler,[35] but a wider application of the method has taken place only in the last several years.[1,10,12,19,25,28,29] The method of using compression varies. Our method consists in using a cellucotton roll and then the ordinary Bucky compression band to exert considerable pressure over the lower abdomen in the region where the ureters cross over the rim of the bony pelvis. It is essential to apply the compression very tightly; if this is done gradually, the patient does not suffer much discomfort. As a rule, the compression is applied for about twenty minutes. This time is usually sufficient to give a good anatomical outline of both renal pelves and the upper portions of the ureters. If excretion is delayed, or if the amount of dye excreted in that time is not sufficient to give a satisfactory shadow of a dilated renal pelvis, as in hydronephrosis, compression is sometimes applied longer. Then the compression is released and the next roentgenogram is taken immediately. This results very often in an excellent demonstration of the entire length of the ureters, because the dye which has been dammed back by the compression immediately rushes down toward the bladder, filling the lower portions of the ureters. After this, roentgenograms are taken without compression. Thus the artificial stasis is eliminated and subsequent roentgenograms give a true picture of the physiological status of the renal pelves and ureters. Many authors object to compres-

sion, calling it an unphysiological method.[30] If this combined technique is used, the objections to compression as an unphysiological method are no longer valid.

It is important to discuss briefly the changes in the pyelogram due to the compression itself, as they may have some bearing on interpretation. It should be stated that in normal animals compression passing, it may be noted that compression is often more effective on the right side than on the left, due to the anatomical differences in the positions of the ureters.[1] As already mentioned, on the pyelograms taken after release of compression both ureters are often demonstrated *in toto*. This is the usual occurrence, and has to be considered normal when this method is used.[2]

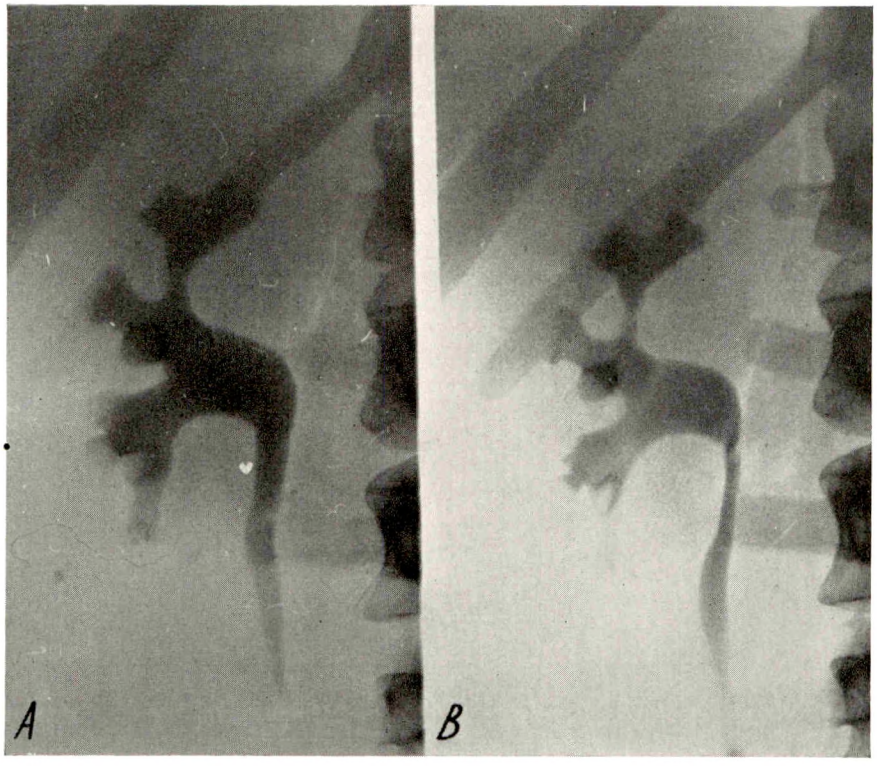


Fig. 1. *A*, normal renal pelvis with compression. *B*, same renal pelvis immediately after release of compression. Note decrease in width of pelvis and ureteropelvic junction.

longer than forty minutes may delay excretion of the dye.[10,33,34] Since the usual examination for diagnostic purposes does not exceed this time, there is no interference with the excretion of dye. The calices and the pelves will appear wider with than without compression, but never to such a degree as to interfere with the interpretation. If one has any doubt whether the renal pelves are of normal width in a given case, comparison with the pyelogram taken without compression will be helpful (compare *A* and *B*, Fig. 1). In pyelography *without* compression, a completely filled ureter is considered a sign of a pathological change, as normal peristalsis interferes with complete visualization of the ureter.[4,7]

The value of compression has been demonstrated by some statistics.[17,23,25] Table 1, taken from Reitan's[25] article, shows that retrograde pyelography was superior to intravenous pyelography with compression in only a limited number of cases.

Reitan[25] also has published a chart showing the enormous increase in urological

Table I*

Cases Examined		Diagnostic Results				Retrograde Pyelography		
Diseases	Number operated upon	Correct (type of diagnosis)	Essentially correct	Wrong or indefinite		Examination unsatisfactory	Gave necessary correction	Determination of pathological side without retrograde pyelography
			Sum					
Renal tuberculosis	49	28	42	14	7	14	0 (8, 4 of which were controls of the normal side)	47 %
Hydro- and pyonephrosis (without stones)	12	5	8	3	4, all as "tumor" diagnosis (large kidney without contrast)		4 (6)	12
Stones	67	66	66		1			67
Renal tumors	19	15	18	3	1	1	8 (11)	18
Renal cysts	4	1	3	2	1	1	0 (3)	4
Bladder tumors	3	2	2		1	1	0 (2 cystographic examination)	

* From Reitan.[25]

examinations by the use of intravenous urography since the technique has been perfected (Chart 1). From this chart it is evident that the examination has been extended to many conditions which would not have been definite enough to warrant

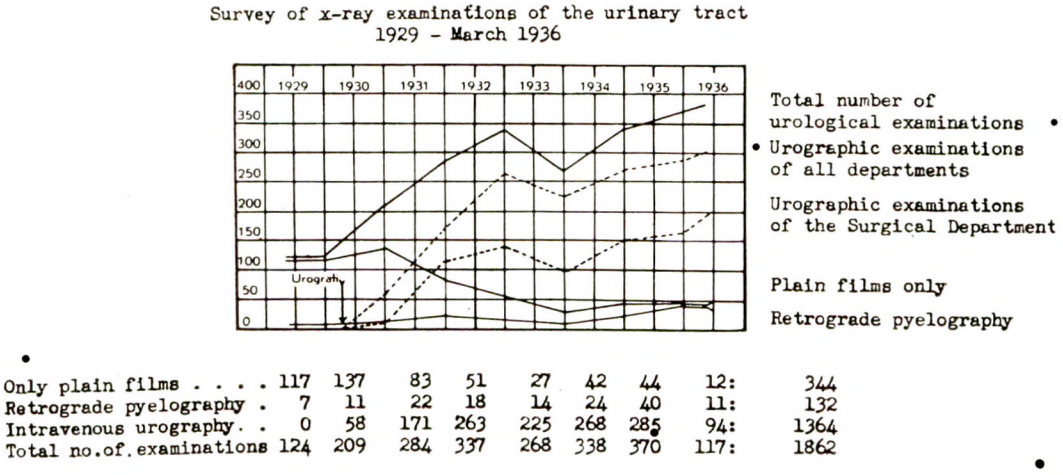


Chart 1*

* From Reitan.[25]

retrograde pyelographic studies, but which, after examination with intravenous urography, turned out to have definite pathological renal changes. Our experience has been similar.

The studies which are to be reported in this paper concern certain observations during intravenous urography to whose explanation not enough attention has been given. The observations, however, are not limited to the intravenous method, but apply even more to the retrograde method.

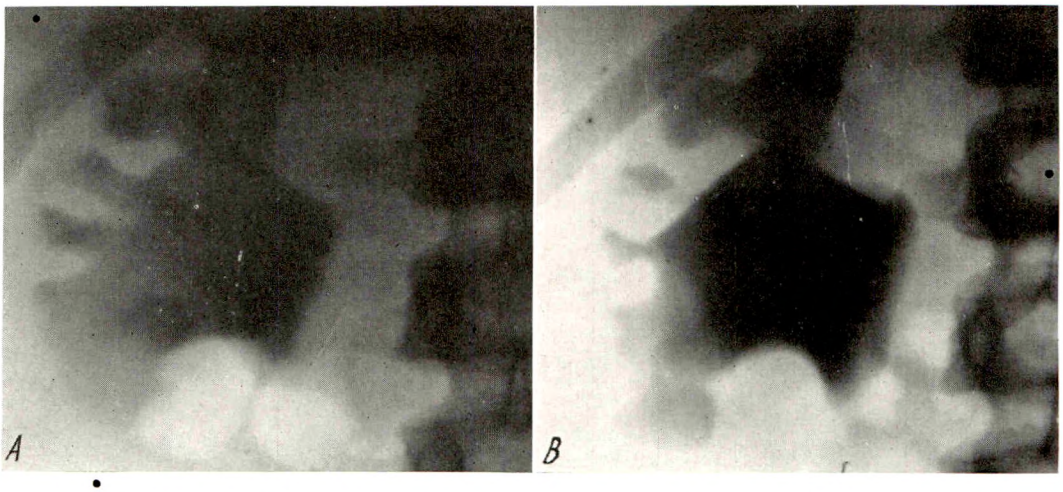


FIG. 2. *A*, pyelogram taken thirteen minutes after intravenous injection of diodrast, showing a straight medial borderline of the renal pelvis parallel to the psoas muscle. The renal pelvis is definitely dilated. *B*, pyelogram of the same renal pelvis taken forty-eight minutes after injection, showing another inner borderline medial to the first.

The first observation which seems to be of considerable interest to us concerns a pyelographic appearance of a renal pelvis, the medial borderline of which is straight and parallel to the psoas muscle. This is by no means a rare occurrence. It is more frequent in cases of hydronephrosis. We have seen it in a great many instances in patients who had more or less dilated renal pelves. A modern textbook of urological roentgenology[32] shows a reproduction of such a renal pelvis with the following legend: "Hypertrophy of the psoas muscle with a deep renal fossa in which the kidney is wedged may result in a distorted hydronephrotic pelvis." Obviously the authors have the conception that the medial straight borderline of the renal pelvis on the pyelogram actually represents the distorted anatomical borderline of this renal pelvis. There has been considerable discussion in the literature, particularly abroad, in regard to this pyelographic observation. Hutter[14,15,16] has published a number of papers on this subject, and has interpreted the finding as evidence of an atonic state of the renal pelvis. He believes that in cases with considerable stasis the renal pelvis becomes dilated and loses its tone, and therefore its shape may be changed by adjacent structures. Ribbing,[26,27] in very interesting papers, has contradicted this opinion. He believes that, at least in retrograde pyelography, stagnant urine is the cause of this phenomenon.

Our observations seem to agree with Ribbing's explanations in regard to the so-called "psoas border sign." In a number of cases of hydronephrosis, if we carried the examination on long enough, we were able to obtain a double medial borderline of the renal pelvis. Figure 2*A* represents a pyelogram taken thirteen minutes after intravenous injection of 20 cc. of diodrast, showing a straight medial borderline parallel to the psoas muscle. Figure 2*B*, taken after

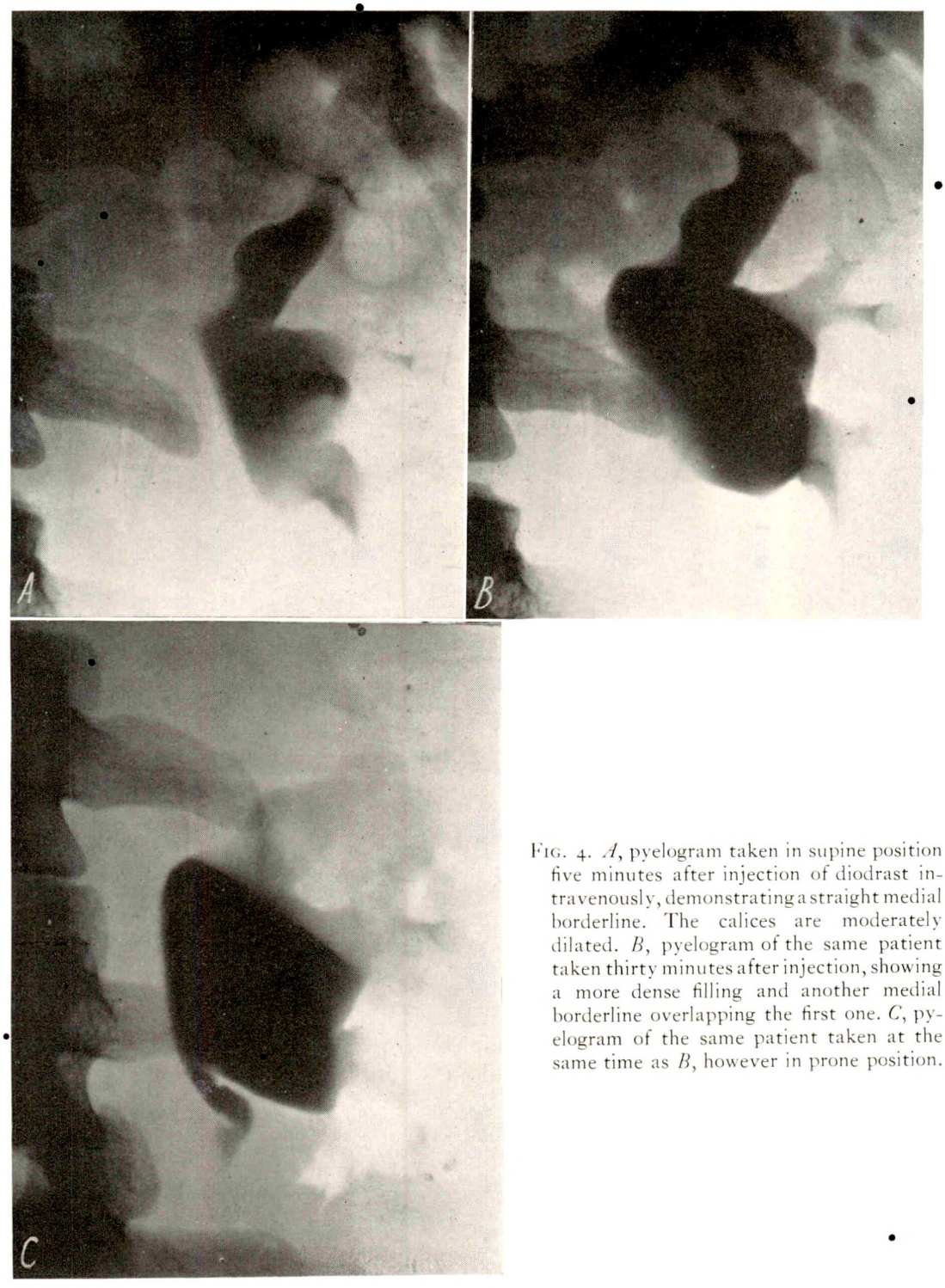


Fig. 4. *A*, pyelogram taken in supine position five minutes after injection of diodrast intravenously, demonstrating a straight medial borderline. The calices are moderately dilated. *B*, pyelogram of the same patient taken thirty minutes after injection, showing a more dense filling and another medial borderline overlapping the first one. *C*, pyelogram of the same patient taken at the same time as *B*, however in prone position.

elography is a generally accepted idea, but the assumption is that the stagnant urine mixes and dilutes the dye, thus producing a fainter shadow.[3] We have found that layer formation can be observed quite frequently in retrograde as well as intravenous urography.

In Figure 4*A* a definite "psoas border

more complete filling (forty-eight minutes after injection) shows another borderline, medial to the first, which conforms to the usual anatomical outline of the renal pelvis. The portion of the renal pelvis between these two medial borders is less dense than the rest. The straight first medial borderline thus continues to be visible on account of different density. This appearance can best be explained by assuming an incomplete mixture of non-contrast urine and dye-containing urine. In order to understand this more completely, we have to remember certain facts about the anatomical position of the kidney and the renal pelvis.

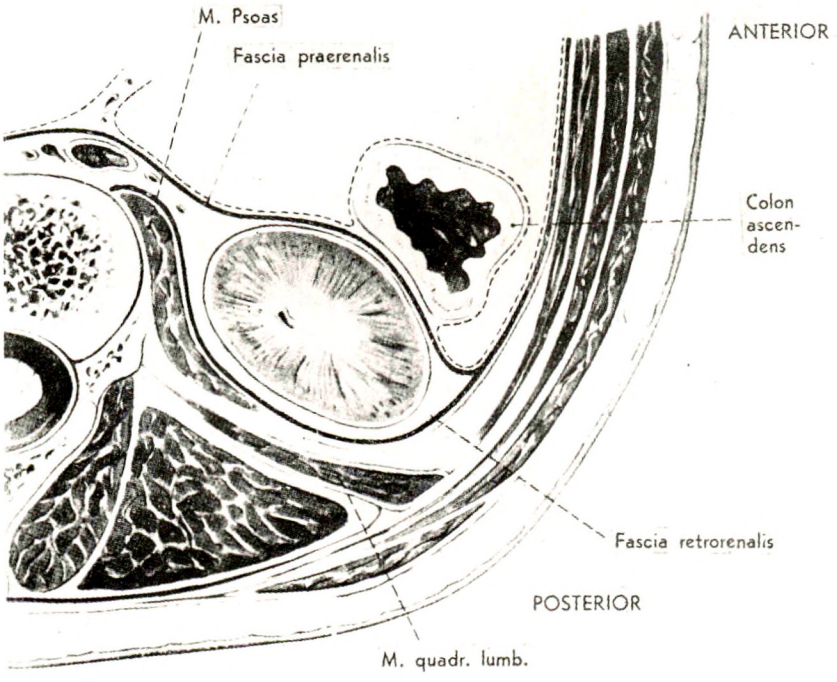


Fig. 3. Cross section of abdomen at the level of the kidney, demonstrating that the medial portion of the renal pelvis is situated more anteriorly and rests upon the psoas muscle.

From Figure 3 it is obvious that the medial portion of the renal pelvis lies anteriorly to the psoas muscle with the patient in the supine position, and represents the highest portion of the renal pelvis.

If non-contrast urine is present in the renal pelvis at the time when the dye-containing urine outlines the renal pelvis, a layer formation of both fluids occurs, the lighter non-contrast urine collecting at the highest point. Therefore the medial, i.e., higher portion of the renal pelvis contains the lighter non-contrast urine and does not become visible on the pyelogram at the beginning of the examination (Fig. 2*A*). In Figure 2*B* enough contrast dye is present to fill also this medial highest portion of the renal pelvis, at least partially, and therefore a shadow is cast outlining the true anatomical borderline of this renal pelvis. This shadow is less dense because this part of the renal pelvis does still contain a small amount of non-contrast urine.

The idea of layer formation in pyelograms is not generally known. That there may be stagnant urine present in the renal pelvis which may interfere with obtaining a good roentgenogram in retrograde py-



Fig. 5. *A*, pyelogram of a renal pelvis taken in supine position thirty minutes after injection, showing definite so-called "psoas border sign." *B*, same renal pelvis taken in the prone position, showing disappearance of the so-called "psoas border sign."

sign" is seen five minutes after injection of dye. In later pyelograms, taken fifteen and thirty minutes after injection, the medial borderline becomes somewhat indistinct, and the straight psoas border of the renal pelvis seems to be overlapped by another, less intense, shadow. The calices of the pelvis, particularly the upper one, appear slightly dilated (Fig. 4*B*). A pyelogram taken thirty minutes after the injection with the patient prone (Fig. 4*C*) shows very strikingly complete disappearance of the so-called "psoas border sign," and a more familiar cone-shaped outline of this portion of the renal pelvis. Simultaneously the dense fluid has drained in this position from the calices, so that only a very faint shadow of them is obtained. These pyelograms show clearly that the heavy contrast dye shifts within the renal pelvis to the most dependent portions, which naturally vary with the position of the patient.

The next pyelogram (Fig. 5*A*) illustrates that filling of the renal pelvis may appear almost complete and still a "psoas border sign" may be observed, simply because of a minute amount of non-contrast urine collecting at the highest point. It disappears as soon as the patient is put in prone position (Fig. 5*B*).

All the previous cases showed the "psoas border sign" in patients with more or less dilated renal pelves, but it can also be observed when the pelves are not obviously dilated (see Fig. 6, *A* and *B*).

An easy way to demonstrate a considerable amount of non-contrast urine in a dilated renal pelvis was furnished by the

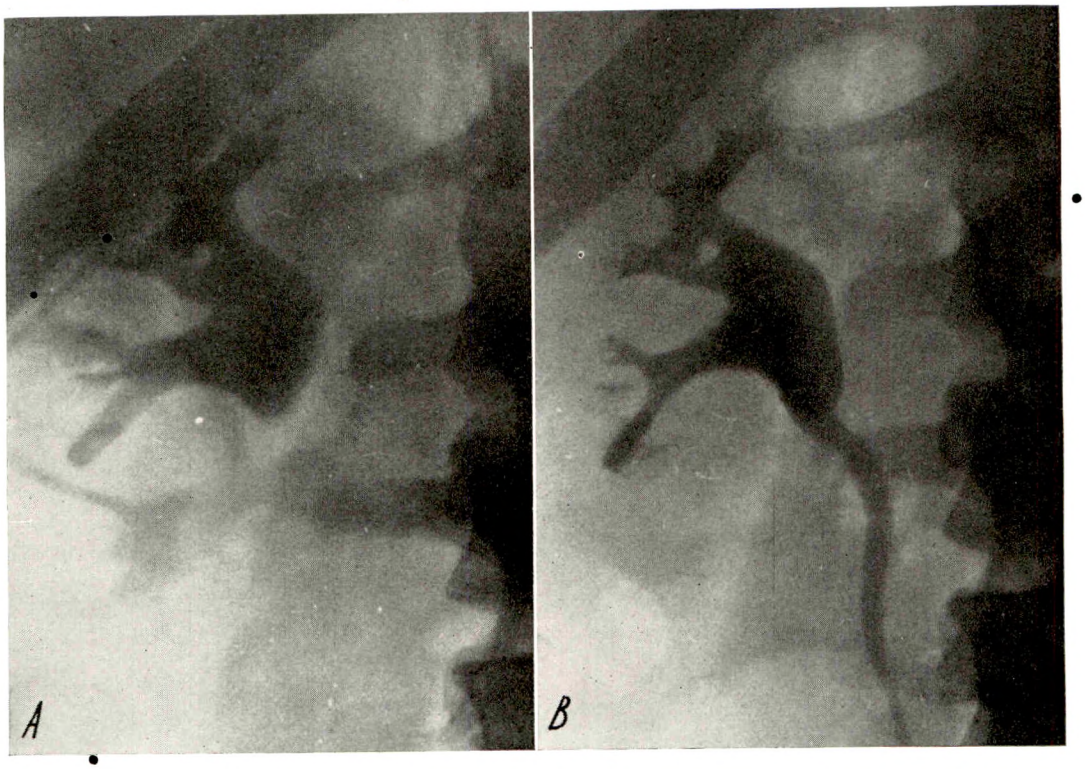


FIG. 6. *A*, pyelogram taken five minutes after injection in the supine position. *B*, same case forty minutes after injection. Note filling of the medial portion of the renal pelvis, which lies more anteriorly than the lateral portion in the supine position.

case of a young woman who had a stone at the lower end of the ureter (Fig. 7). A pyelogram taken with the patient in a lateral position, the ray directed horizontally,



FIG. 7. Pyelogram of a patient with a low ureteral stone taken twenty-five minutes after injection of dye. The patient is in a left lateral recumbent position. The rays are directed horizontally. Note almost horizontal fluid level of the dye.

demonstrated an almost straight upper borderline of the dye, the dye filling only the peripheral minor calices. The routine supine position showed in this instance a hazy outline of several clubbed calices and a dilated renal pelvis.

Aside from the phenomenon of the "psoas border sign," there are other observations in pyelographic studies which become very simple to understand if one is aware of the layer formation of contrast and non-contrast urine. For illustration, an instructive case may be mentioned in which layer formation took place in only a few of the calices of the left renal pelvis. This was a man who had for years complained of colicky pain in the left flank, occurring in attacks and radiating toward the groin. The clinical diagnosis was left renal stone. The plain roentgenogram revealed two stones in the left renal pelvis, a large one, apparently of dumbbell shape, and a smaller one. Intravenous pyelography

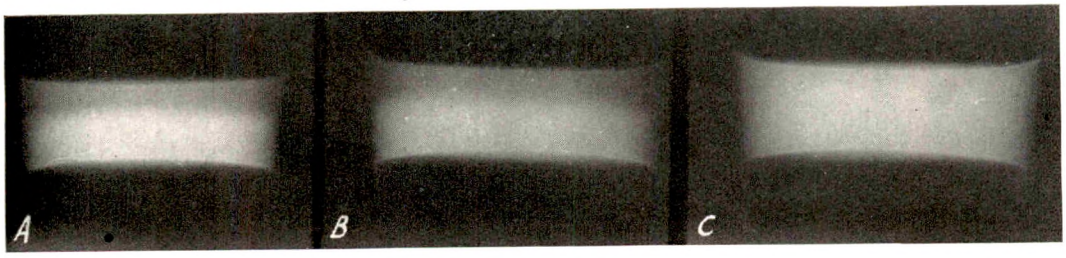


Fig. 9. *A*, layer formation of dye-containing urine and urine immediately after they were poured into the same container. *B*, the same fluids fifteen minutes later. Note that fluids have not mixed. *C*, the same fluids after stirring. Note that layer formation has disappeared.

The patient's urine was collected before intravenous injection of the dye and again collected at the end of intravenous pyelography, when the bladder contained mainly contrast urine, as visualized on the pyelogram. A paper cup was used and the contrast urine was allowed to flow slowly through a ureteral catheter into the normal urine. After the whole quantity of urine had been added, roentgenograms showed that the mixture was not uniform, and the fluids stayed separated for a considerable length of time.

Figure 9 illustrates this experiment with urine whose specific gravity was 1.027 before injection of the dye, and 1.065 at the end of the pyelography. It shows layer formation clearly, the iodine-containing urine forming the lower layer. It should be emphasized that the experiment is successful only if the dye-containing urine is added cautiously, because gross motion or any shaking of the cup containing the fluids will prevent the formation of layers. It may also be of interest to note that a very soft exposure failed to demonstrate the slight difference in densities, and that a certain hardness of exposure is necessary for the demonstration of layer formation (Fig. 10). This may possibly explain why Ribbing[26] was unable to demonstrate layer formation in his experiment with the contrast urine obtained after intravenous pyelography, while he demonstrated the layers when imitating the conditions of retrograde pyelography.

Obviously the possibility for layer formation is present wherever the specific gravity of contrast urine differs sufficiently from the specific gravity of the urine secreted before the injection. The rather low specific gravity of urine in hydronephrosis may be

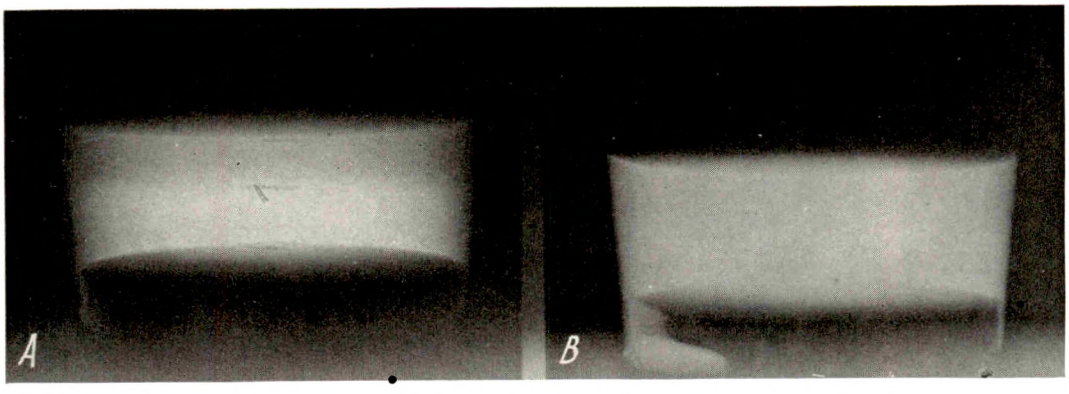


Fig. 10. *A*, layer formation in dye-containing urine and urine. Exposure values: 43 kv., 100 ma., one second. *B*, same with softer exposure: 30 kv., 100 ma., 7/8 second. Note that this soft exposure fails to make the layer formation obvious.

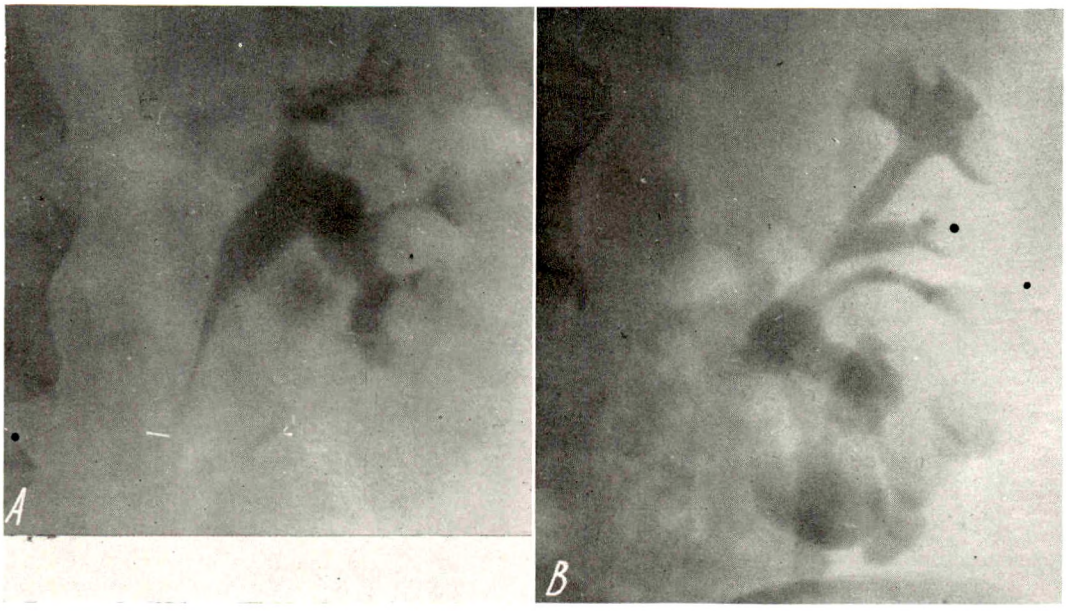


FIG. 8. *A*, normal appearing renal pelvis thirty minutes after injection. However, there is an ill-defined deposit of dye in the lower part of the renal pelvis. *B*, same patient twenty minutes later in the upright position, showing at least four dilated calices at the lower pole partially outlined by dye.

showed that the renal pelvis on the right consisted of numerous minor calices, and that there was an apparently similar renal pelvis on the left side. A pyelogram taken thirty minutes after injection showed no distortion of the left pelvis in spite of the presence of the stone (Fig. 8*A*). There was, however, a small amount of dye outside the dye-filled calices which could not be properly localized. The patient was allowed to leave the roentgen table and walk about. A pyelogram taken twenty minutes later in the upright position showed four markedly dilated renal calices outlined by a small deposit of dense dye at their lower poles, having an indistinct upper borderline, while the remaining parts of these calices were not filled with dye (Fig. 8*B*). These calices were obviously the ones which were blocked by the big renal stone previously described. They contained stagnating urine and the amount of dye which was excreted into them was too small to outline completely these markedly dilated calices in the supine position. When the patient was re-examined in the supine position for comparison with the pyelogram in the upright position, there was not, even after ninety minutes, enough dye in the dilated calices to outline them completely and clearly, but the dye then collected only at the dependent portion, giving an ill-defined deposit which would have been hard to interpret without the pyelogram in the upright position. This case illustrates that the layer formation in pyelography may influence not only the size but the contour of the contrast shadow.

Surprising as it may seem, layer formation in pyelography can be understood easily if one remembers that the specific gravity of contrast urine obtained from a patient after intravenous urography is considerably higher than the specific gravity of the same patient's urine before the intravenous injection of dye.

We were able to demonstrate layer formation experimentally, duplicating the conditions of intravenous urography in the same manner as Laurell[20] and Ribbing[26,27] had done for the conditions of retrograde urography. Ribbing also attempted this experiment, but was unsuccessful. The experiment was carried out in the following manner:

one of the factors leading to layer formation in this condition. However, obviously a more important factor than this is the stasis of urine in hydronephrotic renal pelves. In a normally functioning renal pelvis the residual urine is quickly eliminated by the physiological contractions of the pelvis in the first stages of excretory urography. Our observations on intravenous urography, however, lead us to believe that a small amount of residual urine may occur very readily in a normal renal pelvis.

In the literature layer formation in pyelography has been mentioned, but usually this phenomenon was thought of only when the upright position was used. Thus Hennig and Lechnir[11] recommend strongly a new method of demonstrating a hydronephrotic renal pelvis by the retrograde injection of small quantities of thorotrast. If pyelograms are then taken in the upright position, fluid levels are seen. The authors claim that the results can only be obtained with thorotrast, which, in contrast to all other dyes used, such as uroselectan, does not have the property of mixing thoroughly with the urine. Besides Ribbing, the French authors Lepoutre and Monnier[21] and Heitz-Boyer[9] have observed fluid levels in retrograde pyelography, and in hydronephrotic kidneys following intravenous pyelography, by the use of the upright position. The authors point out that it is important to be familiar with the suppression of the shadow of the upper calix in the upright position, because it contains, of course, the non-contrast urine in this position and therefore is not demonstrated in its outline on the roentgenogram. It may lead to the erroneous diagnosis of a pathological change, such as tumor defect, if one is not aware of this fact.

It should be mentioned that variations in the method of doing pyelographic studies have been recommended by various authors in order to avoid certain errors. Pyelograms in the ventral position have been recommended, or the upright position,[31] particularly for the diagnosis of ptosis, or pyeloscopy[8,13] and aimed exposures,[18] but in most instances the rationale for employing these methods has been to obtain additional projections of the renal pelvis. In the latter papers no mention has been made of the fact that layer formation within the renal pelvis is responsible for the additional information which is often obtained by varying the position of the patient. We believe from our studies that the retention of non-contrast urine and its failure to mix with the dense dye are important factors in obtaining so much additional information, if one varies the positions of the patient. We think that the use of compression and variations in position are often of value in clarifying doubtful findings, especially if one remembers the possibility of layer formation when interpreting pyelograms.

REFERENCES

1. Berger, R. A. Increasing the value of intravenous urography by improvements in technique. Am. J. Roentgenol. & Rad. Therapy, 1937, *38*, 156–161.
2. Boeminghaus. Technik der Röntgenuntersuchung der Harnorgane. *Röntgenpraxis*, 1937, *9*, 727–749.
3. Bowman, W. B., and Goin, L. S. Roentgen findings in some obscure kidney lesions. *Radiology*, 1929, *12*, 188–192.
4. Cumming, R. E. Physiologic data upon renal and ureteral function as recorded by the Jarre cinex camera. *J. Urol.*, 1931, *25*, 613–623.
5. Cumming, R. E., and Chittenden, G. E. Intravenous and retrograde urography; comparative study. *J. Am. M. Ass.*, 1936, *106*, 602–606.
6. Emmett, J. L., and Braasch, W. F. Has excretory urography replaced retrograde pyelography in the diagnosis of renal tuberculosis? *J. Urol.*, 1938, *40*, 15–23.
7. Fuchs, F. Ueber das reflexbedingte Verhalten der oberen Harnwege und seine Bedeutung für die Ausscheidungsurographie. *Ztschr. f. urol. Chir.*, 1932, *35*, 169–179.
8. Gottlieb, J., and Strokoff, F. Ueber die Nephro- und Pyeloröntgenoskopie. *Ztschr. f. Urol.*, 1928, *22*, 257–261.
9. Heitz-Boyer, M. La pyélographie en verticale (verticale simple et double verticale). *Bull. Soc. franç. d'urol.*, Feb. 15, 1937, pp. 46–78.
10. Hellmer, H. On the technique in urography and the roentgen picture in acute renal and ureteral stasis. *Acta radiol.*, 1935, *16*, 51–55.
11. Hennig, O., and Lechnir, J. Spiegelbildung in Sacknieren nach retrograder Pyelographie mit

Thorotrast, eine neue Darstellungsweise erweiterter Nieren. *Ztschr. f. urol. Chir.*, 1933, *37*, 60–77.

12. HODGES, F. M. Intravenous urography. *South. M. J.*, 1939, *32*, 150–154.
13. HRYNTSCHAK, T. Combined pyeloscopy; its clinical value and its technique. *J. Urol.*, 1930, *24*, 549–566.
14. HUTTER, K. Zum röntgenologischen Nachweis von Tonusherabsetzung der oberen Harnwege. *Ztschr. f. Urol.*, 1932, *26*, 809–819.
15. HUTTER, K. Zur Röntgendarstellung der Nierenhohlräume nebst Bemerkungen über die Lagebeziehung des Nierenbeckens zum Musculus psoas. *Ztschr. f. urol. Chir.*, 1930, *30*, 256–263.
16. HUTTER, K. Ueber das sogenannte "Psoasrandsymptom" bei Pyelographie. *Ztschr. f. Urol.*, 1934, *28*, 721–724.
17. JONES, A. E., and ARENS, R. A. Certain diagnostic phases of excretion urography. *Radiology*, 1935, *24*, 169–176.
18. JUNKER, H. Fortschritte der chirurgischen Nierendiagnostik. *Ztschr. f. Urol.*, 1938, *32*, 112–128; 191–207.
19. KORNBLUM, K. Some observations on the use of intravenous urography. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *28*, 1–11.
20. LAURELL, H. On the differential-diagnosis: pyonephrosis or retroperitoneal tumour. *Acta radiol.*, 1924, *3*, 226–227.
21. LEPOUTRE, C., and MONNIER. A propos des niveaux horizontaux du liquide opaque dans l'urographie intraveineuse en verticale. *Bull. Soc. franç. d'urol.*, Nov. 16, 1936, pp. 287–296.
22. LJUNGGREN, E. Studien über Klinik und Prognose der Grawitzschen Nierentumoren, zugleich ein Beitrag zur Frage nach der Genese der Hämaturie. *Acta chir. Scandinav.* (supp. 16), 1930, *66*, 1–363.
23. MOORE, T. D. Limitations of intravenous urography. *South. M. J.*, 1936, *29*, 242–248.
24. PRIESTLEY, J. B. Excretory urography. *Radiology*, 1937, *28*, 559–564.
25. REITAN, H. Prinzipien und Erfahrungen betreffend die Urographie. *Acta radiol.*, 1937, *18*, 578–593.
26. RIBBING, S. Une source d'erreurs négligée dans l'interprétation des pyélographies. *Acta radiol.*, 1933, *14*, 545–556.
27. RIBBING, S. Ueber das sog. "Psoasrandsymptom" bei Pyelographie. *Ztschr. f. Urol.*, 1934, *28*, 306–310.
28. STEWART, W. H., ILLICK, H. E., and KENYON, H. R. Special device for ureteral compression in intravenous urography. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 254–255.
29. SWICK, M. Excretion urography with the use of iopax (uroselectan). Oxford Surgery, 1935, Vol. III, Part II.
30. VON LICHTENBERG, A. Principles and new advances in excretion urography. *Brit. J. Urol.*, 1931, *3*, 119–165.
31. WESSON, M. B. New pyelographic technique. *Am. J. Surg.*, 1934, *23*, 284–286.
32. WESSON, M. B., and RUGGLES, H. E. Urological Roentgenology. Lea & Febiger, Philadelphia, 1936.
33. WILCOX, L. F. Kidney function in acute calculous obstruction of the ureter. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *34*, 596–605.
34. WULFF, H. B. Urography in 125 cases of acute renal and abdominal conditions. *Acta radiol.*, 1935, *16*, 77–86.
35. ZIEGLER and KOHLER. Quoted from: Süring, B. Ueber die Bedeutung und Technik der doppelseitigen Harnleiterkompression für die intravenöse Pyelographie. *Ztschr. f. Urol.*, 1933, *27*, 98–102.

Vol. 49, No. 6

VARIABILITY IN ONSET OF OSSIFICATION IN EPIPHYSES AND SHORT BONES OF THE EXTREMITIES*

By IDELL PYLE, M.S., *and* L. W. SONTAG, M.D.
YELLOW SPRINGS, OHIO

THREE recent studies, those of Francis[2] and Francis and Werle[3] and of Flecker,[1] have added much to our knowledge of the age when bone begins to appear in those cartilaginous areas which are to be replaced entirely by bone after birth. Flecker's paper was published last, and contains an extensive review of the pertinent medical and anatomical findings. He compares his work on time of ossification and fusion in epiphyses throughout the body with the findings on record. The papers of Francis and Werle are covered in his review so that further reviewing at this point seems superfluous.

Flecker had hoped to collect all previous publications and include them with his own work in formulating a distribution scale for time of ossification for each center. He found that he could not do this because few of the investigators described their population samplings clearly or told how many children were included in their studies. Many made statements about time of appearance but failed to say how they had arrived at these figures. Francis and Werle described their group and gave the number of cases included, but confused the issue further by suggesting that only the 80th percentile of the group should be used to calculate the mean age for onset of ossification in each epiphysis. Flecker concludes by stating that in spite of the extensive studies published on time of ossification, one still has difficulty in finding a statement about the average time of appearance in terms which are clear enough to decide what the limits of normality are.

Prior to the publication of Flecker's paper we had encountered the same difficulty and we agree with his criticisms. We found, too, that there is one idea which is common to all studies of ossification time with which we are familiar, which confuses the issue as much as any idea which Flecker criticized. This is the universal practice of assessing onset of ossification in terms of the date when the roentgenogram is taken. Francis and Werle calculated their tables for age of appearance from the ages when they saw the bone center for the first time on a roentgenogram. Their roentgenograms were taken at three or six month intervals. Therefore an epiphysis which began to calcify at about four months was assigned the skeletal age of six months, since that was the first roentgenogram in which it was seen. All investigators, including Flecker, have followed the same procedure. When one is setting up a standard, a large error is introduced by this practice unless every child included in the study has had an extensive series of roentgenograms taken at closely spaced intervals. We have therefore estimated from serial reontgenograms on each child the *actual* time when each cartilaginous center began to be replaced by bone. We have found it easier to assess the time of appearance of a center than it is to judge the time of appearance of later maturational features, although the latter has been done successfully by Flory[4] and Todd.[5] After spreading each child's series out and assigning epiphyseal bone age according to the preceding rate of development, size and form of the new bone center, we calculated the means given in Tables I and II from the data. Sixty-one centers were assessed. The epiphyseal centers for the middle third, fourth, fifth and the distal fifth phalanges of the toes were omitted because they tend to bud directly off the primary center or are never formed. The norms presented here are means, not 80th

* From the Samuel S. Fels Research Institute, Antioch College, Yellow Springs, Ohio.

TABLE I

TIME AND ORDER OF ONSET OF OSSIFICATION
(boys)

Order of Appearance	No. of Boys	Mean Age in Months	Standard Deviation (months)	Coefficient of Variability (per cent) $100 \times \frac{SD}{M}$
1 Distal femur	50	0	0.1	
2 Proximal tibia	50	0.1	0.3	
3 Cuboid	50	0.5	0.7	
4 Head of humerus	50	0.7	0.8	
*5 Capitate	50	2.4	1.8	±73.1
*6 Hamate	50	3.4	2.2	67.2
7 Distal tibia	50	3.9	1.5	37.5
8 Head of femur	50	4.4	2.0	45.9
*9 Lateral cuneiform	50	4.4	4.3	97.8
*10 Capitulum	50	6.3	4.3	68.3
*11 Gt. tuber. humerus	50	11.4	7.2	63.3
12 Distal fibula	50	12.5	4.1	33.0
13 Distal radius	50	13.0	4.7	36.2
14 Prox. 3rd finger	50	16.2	5.3	33.0
15 Distal 1st toe	50	16.8	5.6	33.5
16 Prox. 2nd finger	50	17.3	5.0	28.9
17 Prox. 4th finger	50	17.7	5.4	30.8
18 Metacarpal II	50	17.9	5.1	28.3
19 Distal 1st finger	50	18.4	6.2	33.9
20 Prox. 3rd toe	50	19.5	5.2	26.5
21 Prox. 4th toe	50	21.0	5.1	24.3
22 Metacarpal III	50	21.1	6.4	30.2
*23 Medial cuneiform	50	21.9	9.9	45.1
24 Prox. 5th finger	50	22.2	5.6	25.4
25 Prox. 2nd toe	50	22.2	5.8	26.2
26 Metacarpal IV	50	23.6	7.1	29.9
27 Middle 3rd finger	50	24.9	7.6	30.6
28 Middle 4th finger	50	24.9	7.8	31.2
29 Metacarpal V	50	26.0	8.0	30.5
30 Middle 2nd finger	50	26.9	7.5	27.8
*31 Triquetral	50	27.3	15.9	58.4
32 Metatarsal I	50	27.7	4.7	17.1
33 Distal 3rd finger	50	27.8	6.4	23.2
34 Distal 4th finger	50	28.3	7.0	24.7
*35 Middle cuneiform	50	28.4	11.2	39.4
36 Metacarpal I	50	29.8	7.3	24.4
37 Prox. 1st toe	50	29.9	5.8	19.3
38 Prox. 5th toe	50	32.0	5.9	18.4
*39 Navicular (foot)	50	33.4	13.5	40.3
40 Metatarsal II	50	33.4	6.8	20.4
41 Prox. 1st finger	50	34.8	7.9	22.6
42 Distal 2nd finger	48	37.0	7.9	21.4
43 Distal 5th finger	48	37.4	7.4	19.7
44 Middle 5th finger	48	40.3	11.7	29.0
45 Metatarsal III	47	41.5	7.9	19.0
46 Gt. troch. femur	48	42.6	7.6	17.9
*47 Lunate	48	46.0	19.3	42.3
48 Proximal fibula	46	47.0	11.8	25.2
49 Metatarsal IV	46	48.7	9.0	18.5
50 Distal 4th toe	44	51.2	10.1	19.8
51 Patella	36	51.9	11.6	22.4
52 Distal 3rd toe	44	53.5	11.2	20.9
53 Metatarsal V	45	53.6	10.6	19.7
54 Distal 2nd toe	41	57.0	11.4	20.0
55 Navicular hand	38	60.1	14.1	23.4
*56 Proximal radius	37	63.5	17.2	27.1
*57 Greater multangular	39	64.3	19.7	30.7
58 Lesser multangular	36	64.4	15.2	23.6
59 Med. ep. humerus	37	73.6	17.5	23.8
60 Distal ulna	31	82.4	10.6	12.9
61 Epiph. calcaneus	31	89.6	14.0	15.6

TABLE II

TIME AND ORDER OF ONSET OF OSSIFICATION
(girls)

Order of Appearance	No. of Girls	Mean Age in Months	Standard Deviation (months)	Coefficient of Variability (per cent) $100 \times \frac{SD}{M}$
1 Distal femur	50	0		
2 Proximal tibia	50	0.1		
3 Cuboid	50	0.4		
4 Head of humerus	50	0.9		
*5 Capitate	50	2.3	2.1	92.1
*6 Hamate	50	2.5	2.3	91.7
7 Distal tibia	50	3.4	1.4	41.2
8 Head of femur	50	3.7	1.6	44.1
*9 Lateral cuneiform	50	3.8	4.4	115.6
*10 Capitulum	50	4.1	3.6	87.5
11 Gt. tuber. humerus	50	6.6	3.3	49.4
12 Distal fibula	50	9.3	2.6	28.5
13 Prox. 3rd finger	50	10.4	3.1	29.7
14 Distal 1st toe	50	10.6	2.8	26.5
*15 Distal radius	50	10.8	4.4	41.1
16 Proximal 2nd finger	50	11.0	3.0	27.4
17 Proximal 4th finger	50	11.1	3.2	29.1
18 Proximal 3rd toe	50	12.2	3.8	30.8
19 Distal 1st finger	50	12.8	5.0	38.9
20 Metacarpal II	50	12.8	3.7	29.0
21 Proximal 4th toe	50	13.6	3.8	28.0
22 Proximal 2nd toe	50	14.1	3.8	27.2
23 Metacarpal III	50	14.2	4.0	28.4
24 Proximal 5th finger	50	15.2	4.2	27.5
25 Middle 4th finger	50	15.8	4.8	30.2
26 Middle 3rd finger	50	15.9	4.9	30.8
27 Metacarpal IV	50	16.0	4.1	25.9
*28 Medial cuneiform	50	16.7	8.5	50.7
29 Metacarpal V	50	17.2	4.7	27.4
30 Middle 2nd finger	50	17.3	5.2	30.0
31 Distal 4th finger	50	19.9	5.9	29.8
32 Metatarsal I	50	20.1	3.3	16.6
33 Distal 3rd finger	50	20.2	3.9	19.4
34 Metacarpal I	50	20.3	5.3	26.0
35 Proximal 1st toe	50	20.3	5.5	27.1
*36 Middle cuneiform	50	21.3	7.6	35.8
37 Proximal 5th toe	50	21.3	4.8	22.4
38 Proximal 1st finger	50	21.6	5.1	23.8
*39 Triquetral	50	23.6	13.7	57.9
40 Middle 5th finger	50	24.9	7.9	31.7
41 Distal 5th finger	50	25.5	7.0	27.6
*42 Navicular (foot)	50	25.8	11.1	43.3
43 Metatarsal II	50	25.8	6.1	23.6
44 Distal 2nd finger	50	25.8	6.9	26.9
45 Metatarsal III	50	29.1	6.4	21.9
46 Gt. troch. femur	50	29.8	6.4	21.5
47 Distal 4th toe	50	30.7	7.9	25.9
48 Proximal fibula	50	32.6	9.3	28.5
49 Distal 3rd toe	50	32.8	7.7	23.6
50 Metatarsal IV	50	34.0	7.2	21.2
*51 Lunate	50	34.6	14.2	41.1
52 Patella	43	34.8	8.5	24.6
53 Distal 2nd toe	50	35.5	7.3	20.5
54 Metatarsal V	50	38.6	8.4	21.7
55 Med. ep. humerus	47	41.3	9.9	24.1
*56 Greater multangular	46	47.0	14.8	31.5
57 Proximal radius	46	47.5	12.1	25.4
58 Navicular hand	45	47.8	12.3	25.7
*59 Lesser multangular	44	48.3	14.8	30.6
60 Distal ulna	42	63.2	15.3	24.3
61 Epiph. calcaneus	42	63.7	11.8	18.4

percentiles such as have sometimes been used by other investigators[3] in constructing norms for ossification.

We have not found evidence that illnesses common to this age level have a specific delaying action on all centers which are due to calcify just at the time when the illness occurs. Our means and deviations are being used to test this point further.

CHILDREN INCLUDED IN THE GROUP

Sixty-four boys and 69 girls were included. They are all white, are American born, and are selected from the Fels Research Institute children solely on the basis of the completeness of their roentgen series. They tend, as a group, to be better than average in health, mental development and social and economic endowment. They do not, however, represent any one economic class and are not to be regarded as representing only a privileged group.

We restricted the number of assessments for an epiphysis to 50 for each sex in order not to weight the earlier appearing centers unduly, since some of the children are too young to have acquired all 61 ossification centers. No child was used just once.

The *order* of ossification is much the same for the average as for the 80th percentile, or 20th percentile, with a few significant exceptions. It has long been suggested that the irregular bones of the hand and foot appear in atypical order in relation to other centers when growth is either markedly accelerated or greatly retarded. The degree of variability in time of appearance of each center is expressed in Tables I and II in terms of standard deviation and coefficient of variability, the latter being a function of standard deviation and mean (coefficient of variability = $100 \times SD/M$). Within ± 1 standard deviation from the mean age in months for any center, approximately 68 per cent of the children will have acquired an ossification center. Therefore if calcification begins in an epiphysis more than 1 S.D. early or late the center must be considered as falling in the most advanced or most retarded 16 per cent of our group as the case may be, as regards the actual age for onset of ossification for that epiphysis. It is obvious that those centers due to appear at four years may vary more in actual months (and therefore have a larger standard deviation) than those due at four months, but the percentage variation is less. For example, the head of the femur in boys, due at 4.4 months is much delayed (nearly 50 per cent) if that is not seen by 6.4 months while the fourth metatarsal due at 48.7 months is only about 4 per cent late if delayed two months. Therefore, coefficients of variation tend to decrease as one follows down the list of centers from the earlier appearing centers to the late ones. The tendency to greater variability in onset of ossification of carpal and tarsal bone centers as contrasted with epiphyses of long bones is shown by their greater coefficients of variability and greater standard deviation as compared with other centers due to appear at comparable ages. We have starred these centers in Tables I and II. The capitate and hamate in boys have coefficients of variability of 73 per cent and 67 per cent respectively as compared with 38 per cent and 46 per cent for distal tibia and head of femur. Similarly at a later age level triquetral has a coefficient of variability of 58 per cent compared with 28 per cent and 17 per cent for middle second finger and the first metatarsal appearing at about the same ages.

SUMMARY

Tables of time of ossification, including means, standard deviations and coefficients of variability, are calculated by interpolation for sixty-one centers. The material used for the compilation of these data consisted of serial roentgenograms of all extremities of the left side, on 64 white boys and 69 white girls, many of whom have been roentgenographed from birth to the age of nine years. Standard deviations and coefficients of variability are presented. Carpal and tarsal bones are definitely more variable in time of appearance than are true epiphyses. Nevertheless, there is no

marked difference in *order* of ossification in advanced or retarded children or those growing at an average rate. The sex differences in order of ossification given in Tables I and II seem to us to be largely artifacts of sampling. We have not been able to find adequate evidence of the specific delaying action on certain centers, of illness occurring just previous to calcification of these centers.

REFERENCES

1. Flecker, H. Time of appearance and fusion of ossification centers as observed by roentgenographic methods. Am. J. Roentgenol. & Rad. Therapy, 1942, *47*, 97–159.
2. Francis, C. C. Factors influencing appearance of centers of ossification during early childhood. *Am. J. Dis. Child.*, 1940, *59*, 1006–1012.
3. Francis, C. C., and Werle, P. B. Appearance of centers of ossification from birth to 5 years. *Am. J. Phys. Anthrop.*, 1939, *24*, 273–299.
4. Flory, C. H. Osseous Development in the Hand as an Index of Skeletal Development. Monographs of the Society for Research in Child Development. 1936, *1*, No. 3, 1–141.
5. Todd, T. W., and others. Atlas of Skeletal Maturation. Part 1. Hand. C. V. Mosby Co., St. Louis, 1937.

ondary atrophic changes occurring after treatment must be borne in mind.

Figi,[5] of the Mayo Clinic, reported in 1929 the treatment with radium of 13 cases of multilocular lymph cysts of the neck. The dosage used was 3,000–7,000 mg-hr. at 2.5 cm. distance and 2 mm. lead screening, which was repeated every two to three months up to as many as nine treatments. Three of the 13 cases were entirely well at the time the report was made, 2 had regressed, 1 showed no change, and 7 died of acute infection of the tumor while treatment was being carried out. (It should be noted, however, that 4 of the last group were infected before treatment was begun.)

Andrews[2] in 1938 had treated 8 cases of lymphangioma circumscripta, but none of the cavernous type. In 1940, he[3] supplemented his earlier report with the conclusion that these tumors did not respond favorably to radium treatment, although exceptions to the rule were possible.

An extensive study of the treatment of 41 cases of lymphangioma at the Memorial Hospital, New York, was reported in 1940 by Watson and McCarthy.[8] In general, they advocate surgery followed routinely by irradiation in order to control recurrence and prevent keloid formation. If removal of the tumor was incomplete radon seeds might be planted in the remaining portion. Seventy-seven per cent of the cases so treated improved; in 4, the tumor recurred and required a second operation. Eighteen cases were treated by irradiation alone and all developed marked skin damage. In 35 per cent the results were good; in 25 per cent, poor. These authors considered cystic hygromas of the neck as a separate group, in which, up to 1929, they had had a mortality of 54 per cent with radium treatment. Later their results were more satisfactory with the injection of sodium morrhuate before irradiation. If this treatment failed surgery was resorted to; if surgery was incomplete irradiation was given in some instances.

Stewart and Farrow[7] in a discussion of the radiosensitivity of tumors acknowledge that lymphangiomas are more resistant than the hemangiomas, and that while the superficial small lesions of the extremities show a certain sensitivity, the deep lesions are definitely resistant. They do not encourage radiation treatment of cystic hygromas.

Cutler, Buschke and Cantril[4] believed that treatment of cystic hygromas should be limited to careful surgical excision.

MacKee[6] in 1938 reported 3 cases which had been treated without resultant change in the tumor.

REVIEW OF CASES

We have examined the records of 12 cases treated with roentgen rays or radium at this hospital during the years 1930 to 1940 (Table 1), after which time radiation treatment was replaced by surgery as a general procedure. In 2 cases only was the diagnosis confirmed by biopsy. Histopathological classification is therefore impossible, but the clinical diagnosis is probably correct in a high percentage of the group. The use of the biopsy as a means of diagnosing lymphangioma probably should be discouraged since the findings are often inconclusive and because fatalities not infrequently follow infections.

Three patients had one treatment only, and were not seen again in the clinic. They are not included in Table 1. Of the group of 12 cases, 7 showed no benefit from the treatment, and 4 showed a partial disappearance of the lesion. However, the dose required to produce this result also caused some permanent damage to normal tissues. One case in which the lesion was of the verrucous type showed a satisfactory response although the dose given was well below that likely to cause injury to normal tissue.

CONCLUSIONS

The results of this review seem to be quite definite. There is only one form of lymphangioma, the verrucous type of lymphangioma simplex, which responds

VOL. 49, NO. 6

RADIATION TREATMENT OF LYMPHANGIOMA*

By GEORGE W. HOLMES, M.D., *and* LLOYD E. HAWES, M.D.
BOSTON, MASSACHUSETTS

LYMPHANGIOMA is a rather uncommon tumor which is relatively easy to diagnose but extremely difficult to treat. It is usually seen in children or young adults, and frequently causes disfiguring deformities which are a source of great anxiety to the parents and to the patients. The physician called to treat such a patient is confronted with a most difficult problem. Any of the procedures advised at the present time may result in unsightly scars, and those which require repeated punctures of, or injections into, the tumor may cause an infection which is sometimes fatal. The radiologist not infrequently attempts the treatment of these tumors without fully realizing the seriousness of the problem. The fact that lymphangioma resembles hemangioma, a tumor known to respond well to irradiation, and that the name suggests a radiosensitive tumor, may lead him to make a much too favorable prognosis, or to attempt the treatment of the patient without consultation or consideration of other methods of treatment. When, as so frequently happens, the results are unsatisfactory he may find that both his judgment and his treatment are discredited.

The unsatisfactory results obtained with irradiation of these tumors at this hospital has led us to review the literature regarding the treatment of lymphangioma and to report the result of irradiation in 12 treated cases.

CLASSIFICATION

In general, the term lymphangioma includes a considerable variety of slow growing, usually congenital tumors occurring in skin, subcutaneous and deep areolar tissues; but occasionally invading the muscles of neck, tongue, lip and other structures. Single or multiple lesions occur. Histologically they are composed of dilated lymph vessels, the walls of which are formed of endothelial cells and fibrous tissues. Three distinct forms have been described.

Lymphangioma simplex occurs chiefly in the skin, and is composed of an anastomosing network of vessels or spaces of small or medium caliber. They may or may not show evidence of cell proliferation.

Lymphangioma cavernosum consists of a system of closed lymph spaces lined with endothelium, and containing fluid or coagulated lymph.

Lymphangioma cysticum consists of a collection of cysts of varying size, lined with flat endothelium and containing lymph.

Of the three forms, the cavernous is the most common. Some pathologists and most clinicians describe two additional forms—the *verrucous*, which is composed of new, imperfectly formed lymph vessels, and is a true tumor; and the *cystic hygroma*, a form which usually arises in the neck extending upward toward the parotid and ear, and downward to the supraclavicular fossa and even into the mediastinum.

REVIEW OF LITERATURE

In 1927, Andren[1] reported the results of radium and roentgen irradiation in 11 cases of lymphangioma all of which were cavernous and subcutaneous; no biopsies were taken. Of the 7 cases treated with radium, 5 were children; their condition was unchanged. One adult was cosmetically restored although an inflammatory reaction of the second degree was produced by the treatment; 1 showed improvement. Four cases were treated by roentgen irradiation, given in repeated series, using 0.5 mm. copper filtration. Only 1 of these improved under treatment. Of the entire group, 7 cases (64 per cent) were unchanged. Andren concluded that (1) the radiation must be strongly filtered; and (2) the risk of sec-

* Department of Radiology, Massachusetts General Hospital, Boston.

TABLE I

PATIENTS TREATED WITH ROENTGEN OR RADIUM IRRADIATION FOR LYMPHANGIOMA AT THE MASSACHUSETTS GENERAL HOSPITAL 1930–1940

Case No.	Biopsy	Roentgen or Radium Treatment	Surgery and Roentgen Treatment	Improved	Unimproved	Results
13737	0	1	0	1		Small skin lesions; given ulcer dose treatment
13521	0	1	0		1	No improvement
10962	0	1	0		1	No improvement
U223990	1	1	0	1		Verrucous type; much improved
10068	0	1	0		1	No improvement
9104	1		1		1	Lymphangioma of orbit. Radium, no effect; good surgical result
9528	0	1	0	1		Radium result fair
85605	1		1		1	Roentgen treatment failure; surgical result fair
U44964	1	1	1		1	Cheek and orbit. Roentgen treatment failure
9092	0	1	0	1		Some improvement under prolonged roentgen and radium treatment
U230896	0	1	0	1		Roentgen and radium treatment; skin damage
13598	1	1	0		1	No improvement
Total cases 12	5	10	3	5	7	

favorably to irradiation when given in doses which do not cause permanent injury to normal tissue. All other forms either do not respond at all or require a dose larger than can be given with safety.

Infection is a real hazard in the treatment of these cases, particularly in the large tumors of the neck. For this reason the taking of biopsies and the insertion into the tumor of radium in the form of seeds or needles should be discouraged.

REFERENCES

1. ANDREN, G. Radium treatment of haemangiomata, lymphangiomata and naevi pigmentosi. Experiences from "Radiumhemmet," 1909–1924. *Acta radiol.*, 1927, *8*, 1–45.
2. ANDREWS, G. C. Treatment of angioma based on 10 year experience at Vanderbilt Clinic. *Arch. Dermat. & Syph.*, 1938, *37*, 573–582.
3. ANDREWS, G. C. Chapter in: Treatment of Cancer and Allied Diseases. G. T. Pack and E. M. Livingston, Editors. Paul B. Hoeber, Inc., New York, 1940, p. 2027.
4. CUTLER, M., BUSCHKE, F., and CANTRIL, S. T.

Cancer: Its Diagnosis and Treatment. W. B. Saunders Co., Philadelphia, 1938.

5. Figi, F. A. Radium in treatment of multilocular lymph cysts of the neck in children. Am. J. Roentgenol. & Rad. Therapy, 1929, *21*, 473.
6. MacKee, G. M. X-Rays and Radium in the Treatment of Diseases of the Skin. Lea & Febiger, Philadelphia, 1938, p. 658.
7. Stewart, F. W., and Farrow, J. H. Radiosensitivity of Tumors. Chapter in: Treatment of Cancer and Allied Diseases. G. T. Pack and E. M. Livingston, Editors. Paul B. Hoeber, Inc., New York, 1940, p. 131.
8. Watson, W. L., and McCarthy, W. D. Blood and lymph vessel tumors. *Surg., Gynec. & Obst.*, 1940, *71*, 569–588.

VOL. 49, NO. 6

NEW TYPE OF RADIUM LOADING PROTECTIVE DEVICE

By ANDREW H. DOWDY, M.D.,* BENJAMIN DuBILIER, M.D.,† *and* DEAN B. COWIE‡

INTRODUCTION

A RECENT survey of the radiation protection in forty-five hospitals in a total of twenty-four states by Cowie and Scheele[1] has revealed some startling facts. Fourteen of the hospitals included in the survey were without a radium loading protective device. In ten others the loading device was constructed of lead less than 2 inches thick, several of these being only 1/16 or 1/8 inch thick. Special instruments for the handling of radium were lacking or inadequate in twenty-five institutions. Radium storage safes were borderline or inadequate in twenty-nine instances. In the majority of the hospitals the radium was transported to and from the radiological department in inadequate or makeshift carriers.

A number of factors are responsible for the aforementioned defects: (1) a failure on the part of the radiologists to appreciate the relative high degree of exposure in roentgens an individual may sustain to the body and hands in the careless handling of radium; (2) most long handled instruments are cumbersome and time consuming in operation and therefore are not used; (3) the cost of adequate equipment in many instances has been a deterring factor.

It is the purpose of this paper to describe a new type of radium protective device and accessory instruments for the loading and unloading of radium applicators. This equipment and the technique to be discussed, we believe, will overcome the criticisms we have enumerated. The equipment is simple in construction, easy to operate, and enables speedy preparations of radium applicators. At all times there is a lead screen interposed between the radium and the operator's body and hands. The actual exposure in roentgens to the body, hands, and finger tips is extremely small and far below that of any previously published data.

[1] Cowie, D. B., and Scheele, L. A. Survey of radiation protection in hospitals. J. Nat. Cancer Inst., 1941, 1, 767–787.

A COMPARISON OF EXPOSURE BETWEEN OLD TYPE RADIUM LOADING PROTECTIVE DEVICE AND NEW TYPE DEVICE

A study of Chart 1 clearly demonstrates the difference in the exposure factor in roentgens between the new and the old type of protective device used at the Department of Radiology, University of Rochester School of Medicine and Dentistry, and the Strong Memorial Hospital, Rochester, New York. The exposure in roentgens shown in Chart 1A represents the exposure sustained while *loading* the T-tube and colpostat. The time consumed in the process of loading is an estimate. In Chart 1B the exposure in

A MEASUREMENTS MADE WITH OLD RADIUM "ELL"				
TYPE OF APPLICATOR	AMOUNT OF RADIUM	TIME FOR LOADING	EXPOSURE TO BODY IN LOADING	EXPOSURE TO HANDS IN LOADING
T-TUBE AND COLPOSTAT	110 MG.	15 MINUTES (ESTIMATE)	0.05 r	0.55 r
B MEASUREMENTS MADE WITH NEW RADIUM "ELL"				
TYPE OF APPLICATOR	AMOUNT OF RADIUM	TIME FOR LOADING AND UNLOADING	EXPOSURE TO BODY IN LOADING AND UNLOADING	EXPOSURE TO HANDS IN LOADING AND UNLOADING
T-TUBE AND COLPOSTAT	75 MG.	5.5 MINUTES (MEASURED)	0.001 r	0.008 r

CHART I

* Department of Radiology, University of Rochester, School of Medicine and Dentistry, and Strong Memorial Hospital, Rochester, New York.
† Trainee, National Cancer Institute, National Institute of Health, Washington, D. C.
‡ Research Fellow, National Cancer Institute, National Institute of Health, Washington, D. C.

BODY AND FINGER EXPOSURES IN SELECTED CASES DURING ASSEMBLY OF RADIUM TANDEMS FOR INTRA-UTERINE INSERTION.

CASE	APPLICATOR MATERIAL	RADIUM		L-BLOCK THICKNESS	FORCEPS LENGTH	ELAPSED TIME	EXPOSURE IN r	
		IN APPLICATOR	OTHER OR TABLE				BODY	FINGERS
		MG.	MG.	IN.	IN.	MIN.		
A	RUBBER	85	275	2	10	31	0.02	25
B	SILVER	90	10	¾	8	12	.04	.4
C	RUBBER	75	NONE	NONE	10	10	.06	1.8
D	DO	75	125	NONE	4	20	.08	36

CHART II

roentgens represents that sustained for *both* the *loading* and *unloading* of the respective applicators. The entire process was timed with a stop watch. While there was approximately only 1.5 times as much radium used with the old device as with the new device (110 mg. and 75 mg., respectively), yet there was 50 to 70 times the exposure using the old device as compared with the new device. The exposures shown in Chart 1B are especially significant when contrasted with those obtained by Cowie and Scheele from representative measurements in their survey (Chart 11).[2]

Our old type of protective device had no sides, and the back and bottom were constructed of 1 inch of lead (Fig. 1). The absence of lead sides permitted a direct exposure of the hands and fingers from the radium in the protective device. The temptation to work with short handled instruments was great and practically impossible to prevent with inexperienced workers.

The safety factor of 50 to 70 times over the old type of protective device has been made possible by the construction of a device which is (1) completely surrounded by lead except in front (the open side opposite the body, Fig. 3); (2) the back and bottom have been increased from 1 inch to 2 inches of lead; (3) the radium and the loaded applicators are manipulated by remote control; (4) the design of the new device and accessory instruments makes it possible to greatly shorten the time necessary to load and unload the radium applicators.

[2] By courtesy of Cowie and Scheele and the *Journal of the National Cancer Institute*.

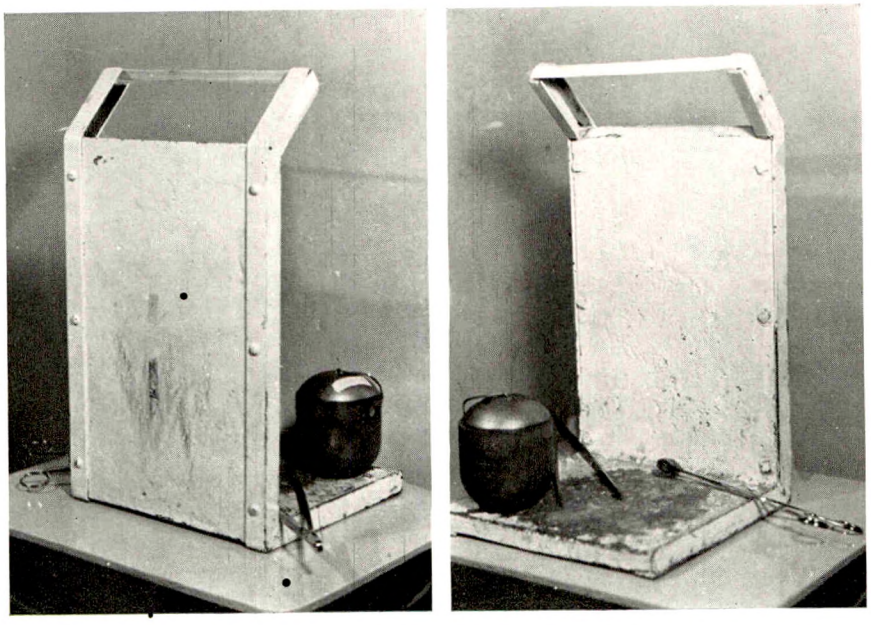


FIG. 1. Back and front views of old radium loading protective device. Note lack of lead side walls. The back and bottom are composed of lead 1 inch thick. There is no plywood covering for back of device.

GENERAL DESCRIPTION OF NEW RADIUM PROTECTIVE DEVICE

The old type of protective device (Fig. 1) should be contrasted with the new device (Fig. 2 and 3). The top, back, and bottom of the latter consist of lead 2 inches thick, and the side walls of lead 1 inch thick. On the left hand side of the bottom is a vise with a universal joint, the remote control handle of which passes through the left side wall of the contrivance. The hole in the lead wall is just sufficient in size to permit the passage of a small solid brass shaft. There is a 1 1/2 inch thick lead collar (Fig. 3, *f*) which fits over the remote control shaft just inside the left wall of the device to block any radiation which may pass through the hole in the wall. A similar hole is in the right side wall on a level with the jaws of the vise, for the introduction of the long handled radium instruments. Each instrument operated through this hole is constructed of a small solid brass rod 12.8 inches in length (Fig. 4), one end (head end) of which is drilled out to accommodate the various sections of the radium applicators. Near the handle it has a 1 1/2 inch lead collar fixed to the shaft to block the emission of radium rays which may pass through the hole in the right side of the device.



Fig. 2. New radium loading protective device, back and side views.

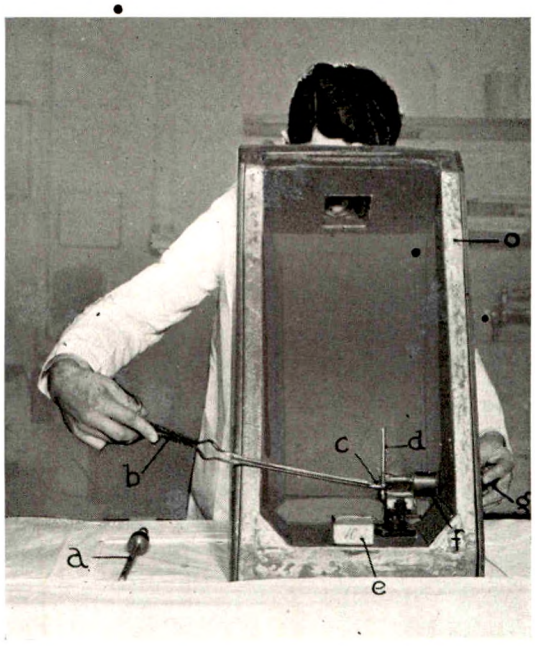


Fig. 3. Front view of new radium loading protective device showing radium being placed into cross arm of T-tube. *a*, long handled radium instrument; *b*, long handled curved forceps; *c*, radium being placed into cross arm of T-tube; *d*, intra-uterine portion of T-tube; *e*, radium well; *f*, lead collar on remote control shaft of vise; *g*, handle for opening and closing vise; *h*, 1 inch lead side wall.

DISCUSSION OF TECHNIQUE USED WITH NEW DEVICE

Before any radium is placed in the well (lead box or block) of the loading device, the first section of the applicator is placed horizontally between the jaws of the vise and held firmly in place by turning the remote control handle at the left side of the device which adjusts the jaws of the vise. The next section of the applicator is then fitted into the hollow or head end of the long handled radium instrument. The head end is then passed through the hole in the

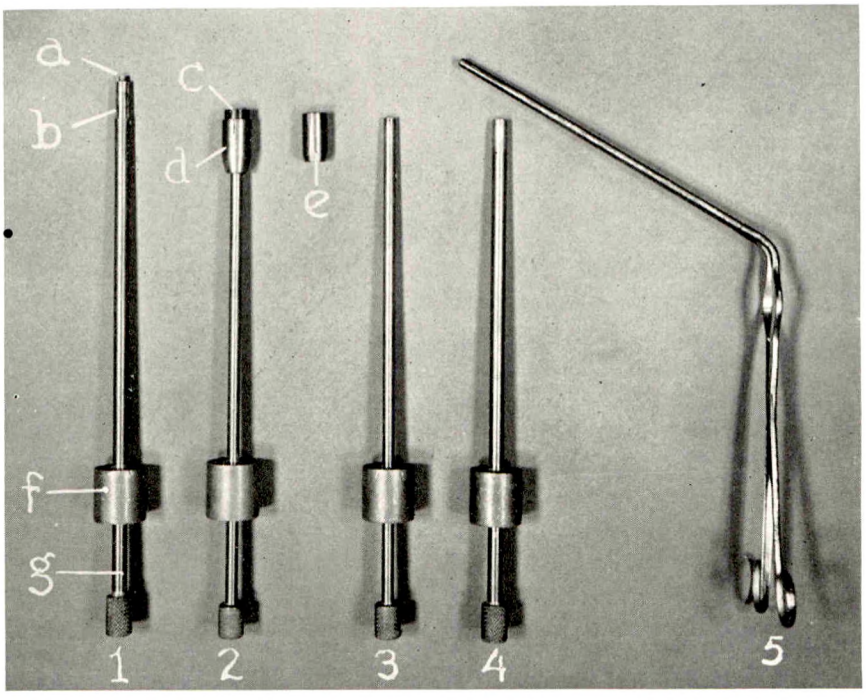


FIG. 4. Accessory instruments for handling radium. *1*, *2*, *3*, and *4* are long handled instruments with a hollow head for the reception of the various sized portions of T-tube and colpostat; *5* is long handled curved radium forceps. *a*, threaded end of section of applicator; *b*, section of applicator in head of instrument; *c*, cap to colpostat in head of instrument; *d*, removable head; *e*, small sized head; *f*, 1½ inch lead collar on shaft near handle of instrument; *g*, handle of instrument.

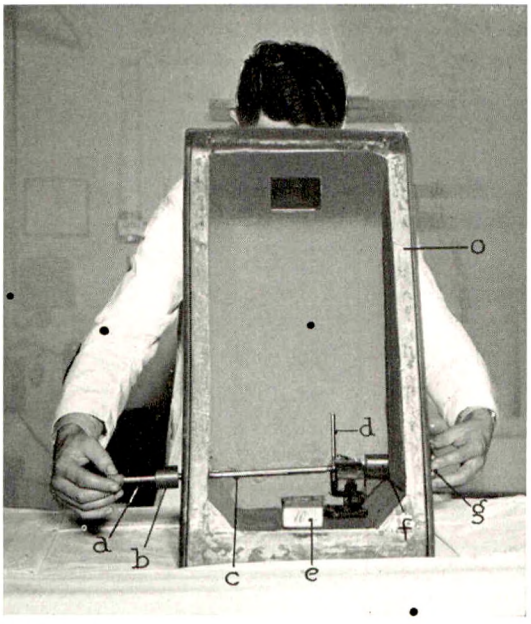


FIG. 5. Cap to cross arm of T-tube is being screwed in place. *a*, handle of long handled radium instrument; *b*, lead collar on shaft of instrument; *c*, shaft of long handled instrument; *d*, assembled sections of intra-uterine portion of T-tube; *e*, radium well; *f*, lead collar on remote control shaft of vise; *g*, handle for opening and closing vise; *h*, lead side wall.

right side of the block. The well containing the required amount of radium is then placed in the device, and by means of a long handled forceps curved at almost a right angle (Fig. 3 and 4) the radium is placed into the first section of the applicator, which is then screwed into place (Fig. 5). The joint of the forceps should be a box joint to insure stability and proper approximation of the tines at the tip. The radium loading instrument is withdrawn from the device, another section placed in the hollow end, and the process repeated until the entire multisectional applicator is loaded and assembled. If the applicator happens to be a straight lead tube a little different technique is necessary. The tube of required length is

made and the base secured in the vise in a vertical position. By using the long handled, curved forceps, the radium is introduced until the applicator is loaded.

At no time are the hands and fingers directly exposed to the radium. The hands are at all times at least 12.8 inches away from the radium. To touch the latter with the fingers would have to be a deliberate and very awkward act.

The ease of manipulation of the new equipment with practice has reduced the time of loading by one-third to one-fifth over that with the older technique. This has resulted in a marked reduction in actual exposure. In addition there is the added protection afforded by the lead sides and the necessarily increased working distance of the hands from the radium.

TESTS SHOWING EXPOSURE IN ROENTGENS WITH VARIOUS APPLICATORS AND AMOUNTS OF RADIUM

Chart III shows the measurements obtained while loading and unloading four different types of radium applicators. The

TYPE OF APPLICATOR	AMOUNT OF RADIUM PER APPLICATOR	TIME IN MINUTES REQUIRED TO LOAD/UNLOAD APPLICATOR.	EXPOSURE IN r TO THE INDIVIDUAL WHILE LOADING AND UNLOADING APPLICATORS FOR A SINGLE PATIENT.		
			BODY	FOREARM	FINGER TIPS
T-TUBE (CARCINOMA OF CERVIX)	55 MG.	6 MIN.	0.003	0.005	0.02
COLPOSTAT (VAGINAL FORNICES)	20 MG.	2 MIN.	0.001	0.001	0.005
STRAIGHT TUBE (INTRAUTERINE TANDEM)	155 MG.	2 MIN. 20 SEC.	0.002	0.004	0.02
RADIUM PLAQUE (SKIN LESIONS, CONTACT)	95 MG.	4 MIN.	0.001	0.004	0.02

Chart III

number of milligrams of radium used in each individual applicator is indicated in the chart, but at all times during the measurements there was a total of 215 mg. of radium in the well of the protective device. *We do not advise having more radium in the well than is to be used in any one preparation.* This excess amount was placed in the well during these measurements to show the high degree of efficiency of the device and accessory instruments. The time and exposure include the loading and unloading, and redistribution of radium. The timing was done by stop watch. The exposures for the body, forearm, and finger tips were measured with three 0.25 r full scale chambers, each division on the scale representing 0.005 r. The chamber measuring the body irradiation was strapped to the back of the device at the level of the chest. The measurement for the forearm was obtained by strapping a second chamber to the medial aspect of the wrist of the operator and a third chamber was held at the finger tips of the operator by a second individual.

TYPE OF APPLICATOR	TOTAL AMOUNT OF RADIUM PER APPLICATOR	EXPOSURE IN r TO THE INDIVIDUAL WHILE LOADING AND UNLOADING APPLICATORS FOR A SINGLE PATIENT		
		BODY	FOREARM	FINGER TIPS
T-TUBE AND COLPOSTAT WITH TOTAL OF 215 MG. RADIUM ON BLOCK.	75 MG.	0.004	0.006	0.025
T-TUBE AND COLPOSTAT WITH NO ADDITIONAL RADIUM ON BLOCK.	75 MG.	0.001	0.002	.008

Chart IV

In order to show the minimal exposure in roentgens under ideal loading conditions the measurements in Chart IV were taken. Here the multisectional, intra-uterine T-tube and colpostat containing a total of 75 mg. of radium, with a total of 215 mg. of radium in the well on the radium block, were loaded and unloaded. The procedure was then repeated with only 75 mg. of radium in the well. Here one notes three to four times less exposure in the latter procedure over the former. *We strongly recommend the latter procedure in all instances.*

THE VALUE OF THE NEW RADIUM PROTECTIVE DEVICE AND TECHNIQUE IN A GENERAL HOSPITAL

The Strong Memorial Hospital and Rochester Municipal Hospital, with a combined bed capacity of approximately 550 beds,

during 1940 cared for 401 cancer patients admitted to the various services during the year. Chart V represents the number of times the various applicators were used with

RADIUM APPLICATIONS USED IN STRONG MEMORIAL HOSPITAL AND ROCHESTER MUNICIPAL HOSPITAL IN 1940		
1	T-TUBE AND COLPOSTAT	26
2	T-TUBE ONLY	6
3	STRAIGHT INTRAUTERINE TANDEM	27
4	INTERSTITIAL NEEDLES	14
5	PLAQUES (LOCAL SKIN TREATMENT)	27
6	SPECIAL APPLICATORS FOR OTOLOGY	33
7	SPECIAL APPLICATORS FOR UROLOGY	349
	TOTAL PREPARATIONS	482

CHART V

a total of 482 different treatments. There were 33 special otological applications and 349 urological applications. In these instances the radium is kept in special applicators which are not loaded and unloaded so that handling is almost entirely avoided.

The annual exposure from radium for the year 1940, not including the special otological and urological treatments, is shown in

TYPE OF APPLICATION AND TIMES USED IN 1940	AVERAGE AMOUNT OF RADIUM AT EACH APPLICATION	EXPOSURE TO BODY IN r	EXPOSURE TO FOREARM IN r	EXPOSURE TO FINGER TIPS IN r
26 - T-TUBE AND COLPOSTAT	75 MG.	0.104	0.156	0.650
6 - T-TUBE ONLY	55 MG.	0.018	0.030	0.120
27 - STRAIGHT TUBE	155 MG.	0.054	0.108	0.540
27 - LOCAL PLAQUES	95 MG.	0.027	0.108	0.540
14 - 10 - 2 MG. NEEDLES	20 MG.	0.056	0.042	0.140
TOTAL ANNUAL EXPOSURE IN r		0.259	0.444	1.990
AVERAGE DAILY EXPOSURE IN r		0.0007	0.0012	0.0055

CHART VI

Chart VI. Here it is seen that the average daily exposure to the body is 0.0007 r; to the forearm, 0.0012 r; and to the finger tips, 0.0055 r, provided that the same individual assumed full responsibility for all radium preparations.

Exposure from loading and unloading a T-tube and colpostat represents the greatest exposure from any combination of applications we are called upon to prepare (Chart III). If we suppose that we received this same exposure from each of the 482 preparations, which certainly is not true, we would have received an annual exposure

482 APPLICATIONS IN 1940	TOTAL EXPOSURE IN r FOR 1940 IN LOADING AND UNLOADING APPLICATORS ASSUMING THAT A SINGLE INDIVIDUAL DID ALL THE WORK.		
	BODY	FOREARM	FINGER TIPS
TOTAL ANNUAL EXPOSURE	0.482	0.964	3.856
AVERAGE DAILY EXPOSURE	0.0013	0.0026	0.0105

CHART VII

far less than what is still considered to be the maximum safe level. If exposure from loading and unloading the T-tube and colpostat without additional radium in the well (see Chart IV) is multiplied by 482, we should get an annual exposure to the body of 0.482 r; to the forearm of 0.964 r; and to the finger tips of 3.856 r. This gives us an average daily exposure to the body of 0.0013 r; to the forearm of 0.0026 r; and to the finger tips of 0.0105 r (Chart VII), provided the same individual assembled and disassembled all the applicators, which is not true in most institutions.

From these data, obtained from actual measurements of time and exposure in roentgens for each of the several representative applicators and then multiplied by the actual number of times these applicators were used in the year 1940, we note a very low average daily exposure. It seems that

in the average general hospital of like size and activity the same individual could handle all the radium and very nearly approach an average daily exposure of 0.005 r. Such an ideal can be approached if the department is so organized as to permit a rotation of the personnel responsible for the preparation of the radium applicators.

CONSTRUCTION OF NEW RADIUM PROTECTIVE DEVICE

Figure 6 shows an isometric drawing representing a view of back, side, and top. Figure 7 represents a view showing side, front, and interior. In this latter view can be seen the location of the vise, universal joint, and lead collar on remote control shaft. The corners of the interior are all reinforced with additional lead which makes a total thickness in these areas of 3 inches. In the actual construction four metal forms can be made representing back, side, bottom, and top according to specifications in the isometric drawings. These forms are filled with molten lead. After cooling and removal of the forms, the respective parts are set in place and fused with a blow torch, the corners are then filled with molten lead by means of a blow torch to fill in any possible crevices and to add structural strength. In making the form for the top, a window must be left which is 4 by 4 by 1 inch and open to the front edge, with a 1 by 4 by 4 inch opening on front and back surface of top to accommodate the 4 inch square lead glass window. To minimize the cost of construction, the window has been reduced to this size from a much larger window in our present model. Should a larger sized piece of lead glass be available or should this additional expense not be an objection, we feel that the larger size is somewhat more

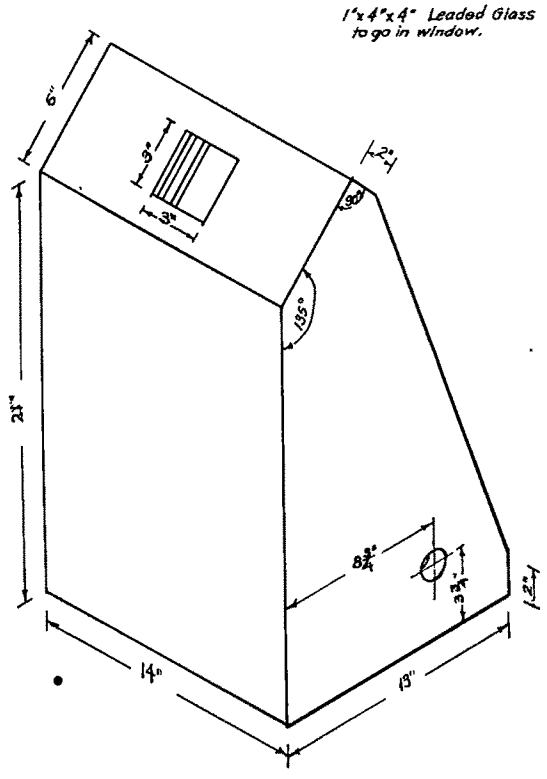


Fig. 6. Isometric drawing of new radium loading protective device showing a view of side, back and top.

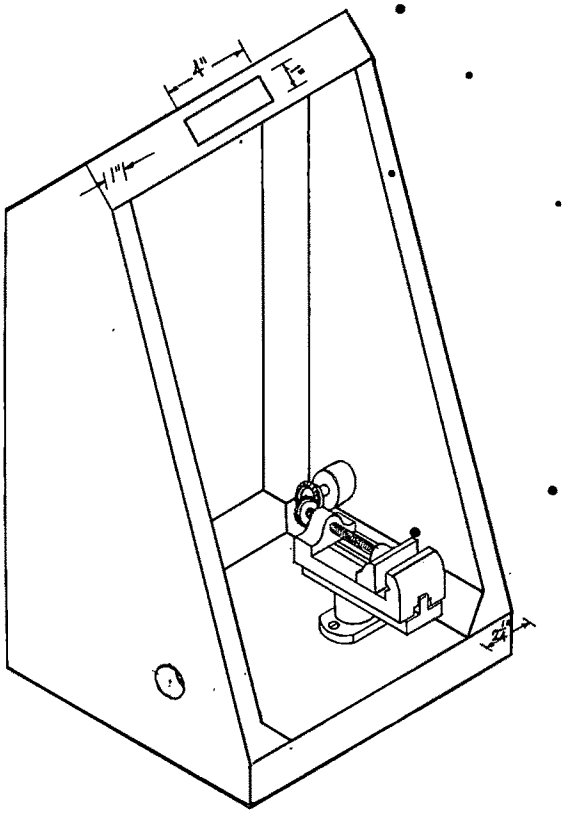


Fig. 7. Isometric drawing of new radium loading protective device showing side, front and interior views.

advantageous. We have noted a tendency for the smaller window to fog from the operator's breath if the room is cool. The device should be radiographed by using 200 mg. of radium for about twelve hours and placing film all over the outside surfaces and corners, to detect holes.

The hole in the left wall to permit the passage of the solid brass remote control shaft is now made. The vise is securely screwed to the base of the contrivance toward the left side and forward. A small soft piece of leather is glued to the approximating surfaces of the jaws of the vise to prevent crushing of the applicators when the grip of the vise is tightened. The lead collar is now placed over the inner end of the remote control shaft and secured in place. A brass bearing is placed in the hole in the wall through which passes the shaft of the remote control handle. The outer end of the shaft is now passed through the left wall and a small wheel secured to its end so that it can be grasped with the left hand for opening and closing the vise. The hole on the right side is to permit the passage of the head of the long handled instruments which manipulate the radium applicators.

The entire outside of the device, with the exception of the bottom and aforementioned apertures, is covered with 1/4 inch of plywood, which not only protects the operator's body from some of the soft secondary radiation from the lead produced by gamma-ray bombardment but also gives a finished appearance.

Following is an itemized account of the cost of material used in construction. The actual construction was carried out in our hospital machine shop.

Lead—536 lb. at $0.08 per lb.	$42.88
Lead glass—16 sq. in. at $0.36 per sq. in.	5.76
Vise	3.85
Material for accessory instruments, etc.	5.10
Total cost of material	$57.59

DISCUSSION

The need for better and more general knowledge of the danger in the handling of radium is again called to the attention of radiologists. The increasing use of radium, both medically and commercially, will increase the exposure hazard to the personnel involved in its supervision and care. We have described a new type of radium loading protective device and discussed a technique which enables the rapid loading and unloading of the various radium applicators with a minimal exposure. The actual exposure in roentgens for loading and unloading the various applicators has been presented in conjunction with a comparison of the exposure received from an old type of protective device.

The increased safety factors with the former is possible because of three factors: (1) increased lead protection; (2) the necessary relatively long working distance of the of the body and hands from the radium, and (3) the increased speed which can easily be developed in the loading and unloading process.

The average daily exposure factors in roentgens from the handling of radium in a hospital of 550 beds in 1940 has been ascertained.

CONCLUSIONS

1. A new type of radium loading protective device is described which is cheap in construction and efficient in time saving and in effecting a low exposure in roentgens to the operator.

2. We believe that with reasonable care the average daily exposure from radium should not exceed 0.005 r in the average hospital.

We wish to express our appreciation to Mr. Charles Albert and Mr. Joseph Ebert of the Maintenance Department of Strong Memorial Hospital and Rochester Municipal Hospital for the actual construction of the protective device and accessory instruments, and their helpful suggestions regarding the various details of design.

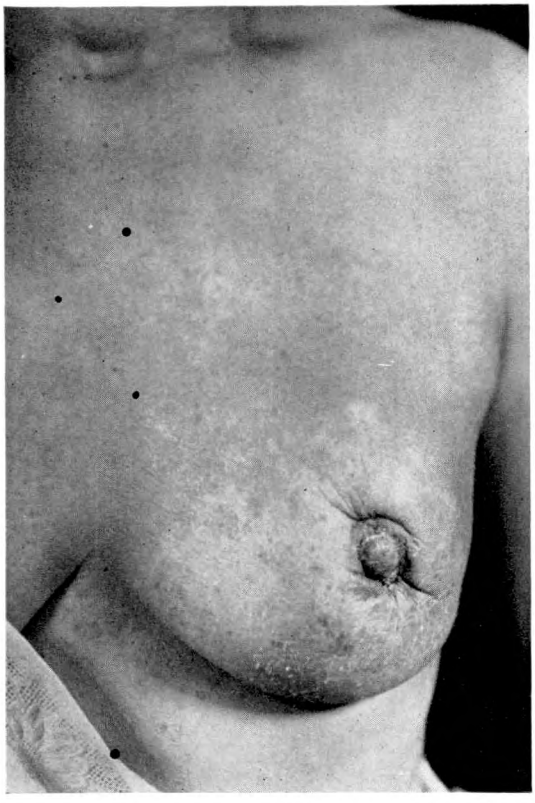


FIG. 1. March 25, 1941. Crown-shaped erythema after irradiation of the breast with 3,000 r from February 20 to March 12, 1941, at 200 kv.

the vessels and nerves of the irradiated part during irradiation. Two methods of procedure have heretofore been recommended for the desensitization of the skin:

A. *Mechanical actions.* Jessen and Rawuski, Schwarz, Christen, Schmidt, Seitz and Wintz used pressure, either exercising pressure directly with compressors of different types or with rubber balloons, or on the limbs, by constriction with rubber bands. According to Schwarz, the pressure brought about in this way increased the tolerance of the skin by 100 per cent.

B. *Physiological actions.* Reicher and Lenz, and Freud introduced adrenalin-novocain by ionization; they applied to the positive pole a compress wet with the active solution and passed through it a current of 10 milliamperes for twenty to twenty-five minutes before irradiation.

These methods of desensitization did not come into general use, doubtless because they were not very practical. Constriction can only be used for the limbs. Pressure on the trunk strong enough to bring about the desired action can rarely be borne by the patient. And the use of ionization is a complication which roentgenologists are apt to reject, even in techniques that require only a few roentgen treatments.

A series of articles appeared describing experimental research by Zondek in which the absorption of folliculin by the skin was described, which had resulted from the use of salves for hypertrichosis, acne, leukoplakia and vulvar pruritus.[3] These suggested the use of active salves for the desensitization of the skin in patients who had to be irradiated for postoperative recurrences of cancer, and whose skins, sensitized by surgical trauma, offered little resistance to the usual skin doses. I at first made use of several commercial anti-hemorrhoidal salves which contained vasoconstrictors and anesthetics and which did not contain any metal excipient which could have made the irradiation injurious. And before every treatment I lightly massaged the skin over the field of irradiation with these salves.*

I found that in patients treated in this way only slight pigmentation or none at all was produced on skins which should have reacted strongly to the doses given.

I then thought of using larger doses than the usual ones for severe cancers and gave the following treatment to a spindle cell cancer of the left tonsil with masses of enlarged lymph nodes (Roch, Case 2,710 of my service): From June 8 to July 4, 1939, 4,200 r was given through a single field with 280 kv., filtered through 1.5 mm. copper and 2 mm. aluminum, focus-skin distance 80 cm.; from July 17 to August 2 1939, 1,200 r over the same field and from August 16 to October 19, 2,800 r, or a total

[3] Mussio-Fournier, J. C., Morato-Manaro, J., and Albrieux, A. Local action of hormones. *Presse méd.*, 1939, *47*, 844–848.

* I extend thanks to Mlle. Mong, superintendent, and to Mmes. Souyri, Moisiard, Gressillon and Stephan, nurses on my service, without whom I could not have treated, and especially followed after treatment, my patients at the Bichat Hospital.

Vol. 49, No. 6

ARTIFICIAL DECREASE OF THE RADIOSENSITIVITY OF THE SKIN AND MUCOUS MEMBRANES IN ROENTGEN THERAPY*

By DR. PIERRE LEHMANN†
Radiologist of the Bichat Hospital
PARIS, FRANCE

THE possibilities of deep roentgen therapy, particularly roentgen therapy of cancer, are limited by skin tolerance. The skin dose is the maximum limit beyond which it is impossible to go in treating a deep lesion; and though the depth dose may be increased in general by improving the depth dose by the use of more penetrating rays and, for central lesions by using cross-fire technique, it nevertheless frequently happens that, in spite of these devices, the depth dose is not large enough to destroy lesions which are not very sensitive to irradiation or which are accessible through only one field.

An attempt has been made abroad to improve radiotherapeutic technique either by increasing the sensitiveness of the tissue to be destroyed or by decreasing that of the tissue to be spared, particularly the skin. I attempted to bring about desensitization of the skin and I was able to accomplish it by a method much simpler and more effective than those which have been in use heretofore.

Radiosensitivity is not a constant property of the skin, but one that varies at different times during the physiological life of the tissue. Schwarz[1] emphasizes the special reaction of organized tissues to roentgen rays. Other physical agents such as heat, cold, electricity and mechanical or chemical agents, cause the same changes, such as coagulation, freezing, oxidation, electrolysis or crushing of organized tissues no matter whether they are living or dead. But with roentgen rays, on the contrary, doses even much larger than those which seriously injure a living tissue do not cause any visible change in the same tissue when it is dead.

It may be assumed, therefore, that a change in the vital processes of a tissue will be accompanied by a change in the reactions of the tissue to roentgen radiation. Schwarz in 1909 showed experimentally that anemia from pressure decreases considerably the sensitivity of the skin to radium. In 1911 Schmidt found that strong pressure brings about inactivity of a dose of roentgen radiation which, without pressure, would cause a second degree skin reaction. Gudzent in 1920 attributed this difference in sensitivity to a physical phenomenon and held that the pressure eliminated secondary radiation emitted by the iron in the hemoglobin of the circulating blood; but Schwarz and Schmidt, having found a decrease and not an increase of radiosensitivity in passive congestion, in which the volume of blood is increased, showed that it was a question of a biological not a physical, process. And the experiments of Rahm and Koose in 1926 on Thiersch grafts and the skin of mice showed that the radiosensitivity of a living tissue is suspended if its connections with the body are severed, and they inserted skin grafts which had been given three to five times the erythema dose in vitro without their showing any lesions from the irradiation.[2]

The method used in practice for desensitizing the skin has been to act on its vascularization and innervation and to suspend more or less completely the action of

[1] In Rieder and Rosenthal. Lehrbuch der Röntgenkunde. Leipzig, 1928, p. 68.

[2] See Rahm. Roentgen therapy in surgery. *Neue deutsche Chir.*, 1927, *37*, 304.

* Translated from the French by Audrey G. Morgan, M.D., Los Angeles, California.
† See Lehmann, P., *Compt. rend. Acad. d. sc.*, June 16, 1941, p. 1103.

of 8,200 r in four months. This resulted in only a dark pigmentation without erythema or desquamation.

As a result of this treatment I repeated my experiment, first using doses larger than the usual skin doses and then decreasing the exposure time of the doses. After having used applications of simple and mentholated vaseline, to prove the part played by the active drugs, without obtaining any results, I used a salve with a base of vaseline and lanolin containing adrenalin and stovaine, excluding the other drugs contained in the antihemorrhoidal salves which I had used before. In September, 1940 as vaseline and lanolin had become scarce, I used lard as an excipient and found that with lard the desensitization seemed to be more complete, doubtless as a result of more complete absorption of the drugs.

I have tried, more recently, to determine whether both the adrenalin and the stovaine were active agents; but I did not think I had the right to risk making the patient lose the benefit of certain desensitization by changing a formula the results of which were known, and I was not able to draw may definite conclusion on this point from the few experiments with semi-penetrating rays to which I limited myself with a stovaine salve without adrenalin.

In the course of these experiments I saw the efficacy of the desensitizing salve demonstrated by finding skin reactions in the form of *pigmentation or annular epidermitis* in a crown around a circle of intact skin in subjects on whom the salve had not been applied entirely to the edge of the field of irradiation (Fig. 1).

It is also noteworthy that the variations in sensitivity of different skins are more marked with the large doses permitted by desensitization than with the usual roentgen therapy. In some very rare cases desensitization seemed less complete than usual, either because the permeability of the skin was defective or because there are, as Freud claims, skins that are resistant to adrenalin.

It would seem also that in summer the use of the salve is less effective, because of the intense heat, which seems to be related to perspiration and may be avoided by preliminary cleansing of the skin.

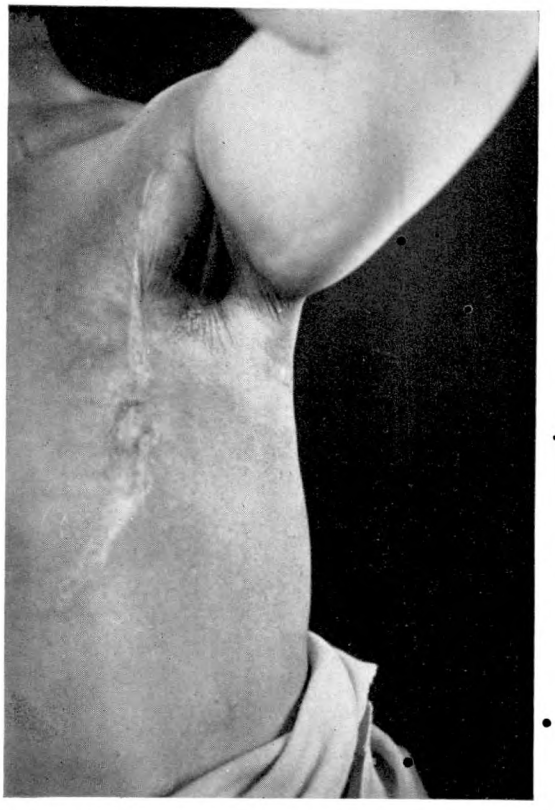


Fig. 2. April 30, 1940. Irradiation of the axilla with 5,000 r from March 13 to April 26, 1941, at 280 kv.

In one case (Case 4,642) the desensitizing salve did not prevent the appearance of a slight skin reaction with desquamation and an inflammation of the buccal mucous membrane after the administration of only 1,750 r with 200 kv. through two fields, one over the right submaxillary and one over the left carotid, or a total of 3,500 r in thirty-four days; but the patient had kept in a bridge during some of the treatments which acted as a radiator of secondary rays, and only the irradiated field had been desensitized for each treatment, while the non-irradiated field was also receiving radiation through a cross-fire action.

The hair follicles do not seem to be affected by desensitization and the epi-

lation dose did not seem to be affected by the desensitizing salve, a fact which it seems to me ought to permit of interesting applications.

At present, after experience acquired in several hundred treatments in the course of which I varied the formula and increased the doses progressively I use the following formula:

Adrenalin	0.01 cgm.
Stovaine	1.00 gm.
Benzoinated lard	100.00 gm.

Before treatment and after cleaning the skin, this salve is applied with a cotton applicator over the whole field to be irradiated. The skin dose which produces a moderate pigmentation without desquamation four weeks after irradiation is, for a skin which has not undergone any surgical trauma, prolonged impregnation with antiseptics or any other cause of sensitization as follows:

3,500 to 4,000 r instead of 2,000 r with 200 kv., filtered through 1 mm. copper and 2 mm. aluminum

6,500 r instead of 3,000 r with 280 kv., filtered through 1.5 mm. copper and 2 mm. aluminum.

These doses were applied to fields 20 cm. in diameter over a period of three to four weeks, measurements being made with the Strauss dosimeter.

With 150 kv. I did not increase the doses in the same proportion, as there is less occasion to increase the doses for patients treated with this voltage. However I have used 1,400 r instead of 1,000 r in the treatment of plantar warts or of Dupuytren's disease.

In a certain number of cases of severe cancer accessible through only one field I even exceeded the doses given above, either by prolonging the irradiation time beyond four weeks or by giving another series of irradiations after an interval of ten to thirty days. For instance (Case 4,741) I gave a dose of 6,000 r with 200 kv. to a scirrhous cancer of the right breast without any reaction except a slight desquamation five days after the end of the irradiation with return of the normal appearance of the skin eight days later. In one case (Case 4,751) of large ulcerated exuberant tumor of the left cheek I gave 6,000 r in forty days without causing any skin reaction. No reaction appeared after 6,000 r in forty days in a case of large epithelioma of the skin of the left leg (Case 4,832).

In an epithelioma of the right lower maxillary region (Case 4,724) the skin desquamated without erythema after the end of irradiation with 280 kv., giving a dose of 7,000 r in thirty days; a month later the skin appeared to be intact and not atrophied. An osteosarcoma of the left knee (Case 4,823) was given 8,000 r in thirty days, 6,000 r on the anterointernal surface, 2,000 r on the posterior surface through large fields; the skin was erythematous without pruritus at the end of the irradiation; some pigmentation persisted thirteen days later.

Intense irradiations may be repeated on desensitized skin without injury after shorter intervals than in the usual treatments. A patient with a large exuberant tumor of the left breast (Case 4,348) was given 5,500 r in twenty-nine days, then after a rest of thirty-five days, 4,500 r in twenty-one days on the same field, or 10,000 r in three months at 280 kv. There was no skin reaction. Another case (Case 4,654) was given 5,000 r in twenty-seven days at 280 kv. for a glandular tumor of the right carotid region, and then after a rest of thirty days 5,000 r in twenty-seven days, or a total of 10,000 r in seventy-four days, the skin remaining intact.

I applied the same technique of desensitization to the pharyngolarynx, using glycerin as an excipient. As complete a painting as possible of the mouth, the tongue and even of the pharynx before each irradiation saves the patients the inflammation of the mucous membrane and the glossitis with disturbance of taste which is so painful toward the end of the irradiations.

In the same way it is possible with

suppositories of adrenalin and stovaine to prevent or lessen the proctitis which often accompanies intense irradiation of the pelvis.

In the eye a desensitizing collyrium prevented conjunctivitis, but the cornea was not protected by the desensitization.

Late roentgen lesions of the cellular tissue might be feared in patients whose desensitized skin had not reacted to large doses of irradiation. So far I have not seen any induration of the cellular tissue or atrophy of the skin with telangiectases in patients who have been under treatment for more than six months. I was justified in substituting this risk of late roentgen lesions for the risk of earlier death in these cases of cancer involving painful complications, which did not react to the usual dosage of irradiation.

The advantages gained in roentgen therapy by desensitization of the skin may be measured by the increase in depth dose which it represents. Cancer therapy has made a step in advance every time the depth dosage has been increased by increasing the voltage of the apparatus. According to Mathey-Cornat the depth dose rises from 38 to 40 per cent of the skin dose with an irradiation at 200 kv. filtered through 2 mm. copper and 1 mm. aluminum with a focal distance of 50 cm. to about 50 per cent for an irradiation at 300 kv. with a focal distance of 60 cm., with fields of the same size in the two cases.

Holthusen and Goggwitzer, Failla, and Mudd claim that the depth dose is increased from 10 to 15 per cent in changing from 200 kv. filtered through 0.5 mm. copper to 700 kv. filtered through 5 mm. copper. Gunsett claimed to have obtained an improvement of 20 per cent in depth dosage on changing from 200 to 400 kv. and of 30 per cent in changing from 200 to 520 kv.[4]

These relatively small gains can be obtained only with apparatus the cost of which rises rapidly with increased voltage and only a limited number of which exist. By the use of desensitization of the skin using the ordinary 200 kv. apparatus the skin dose and therefore the depth dose can be doubled, the depth dose being increased in this way from 40 to 80 per cent of the ordinary skin dose.

It may therefore be said that desensitization of the skin, by increasing the limits of the skin dose, nullifies the advantages of high voltage in roentgen therapy; and as a matter of fact I have found in my service at the Bichat Hospital that the therapeutic results have become as good with 200 kv. as with 300 kv. by making use of the increased skin tolerance brought about by desensitization of the skin.

Desensitization of the skin, therefore, seems to me to offer unhoped for possibilities in the radiotherapy of cancer, thanks to a very simple technical procedure and I have already found a marked improvement in the immediate results of treatment, particularly in cases of severe cancer, those insensitive to irradiation and those accessible through only one field, such as cancers of the breast and of the larynx. And in current roentgen therapy it offers a margin of safety which protects the patient from the risks of radiodermatitis.

[4] La radiothérapie a voltage élevé. *J. de radiol. et d'électrol.*, 1936, *20*, 505–522.

CAVERNOUS HEMANGIOMA OF THE FACE IN AN INFANT TREATED WITH RADIUM

REPORT OF A CASE*

By A. W. JACOBS, M.D.
NEW YORK, NEW YORK

ANGIOMATA of the skin are usually benign congenital anomalies and in about 75 per cent of the cases are present at birth. Although they may occur on any part of the body, about 55 to 60 per cent occur about the head, and about 55 per cent occur as single lesions. They seldom develop in infants after the first year. In reference to etiology the most plausible is the development from embryonic rudiments (Ribbert's theory). Histopathologically the capillary angioma (nevus flammeus and vasculosus) consists of a fine network of capillaries, while the cavernous angioma is composed of dilated blood spaces with thin walls.

Angiomata or vascular nevi generally occur in three forms:

(1) Nevus flammeus (portwine mark)
(2) Nevus vasculosus (strawberry mark)
(3) Angioma cavernosum (cavernous angioma).

(1) *Nevus flammeus or portwine mark* is a pink to blue red area, in size from that of a finger nail or smaller to that of the palm of a hand or larger. It is not raised above the level of the surrounding skin, and usually appears at or shortly after birth. The light pink lesions on the nape of the neck tend to disappear in a few months or years. This type of lesion is not a suitable one for roentgen or radium therapy, although satisfactory response has been seen in small lesions treated early. Grenz rays and the Kromayer lamp have been used.

(2) *Nevus vasculosus or strawberry mark* is a slightly raised, bright red to blue-red lesion, smooth or verrucous. Treatment with radium and carbon dioxide snow produces satisfactory results. The chief advantage of radium therapy is the lack of pain or reaction, both of which occur with the use of carbon dioxide snow. With radium it takes a long time to produce results and may require one to two years for maximum improvement.

(3) *Cavernous angiomas* vary in size from that of a pea to that of a tennis ball or larger. They may be diffuse or circumscribed and are often surmounted by a nevus vasculosus. Radium is the treatment of choice.

The earlier the treatment is instituted, the better and quicker the results. It is advisable to begin before the child is three months old, and two months might be considered as the minimum age—certainly during the first year of life. Early treatment is recommended for three reasons:

1. The endothelial cells lining the vascular spaces of the tumor are more radiosensitive during their embryonic and early life.
2. Early treatment will prevent most lesions from becoming larger and spreading laterally.
3. Residual effects of irradiation such as scarring and increased pigmentation decrease as the years go on, thereby producing better cosmetic results.

The treatment of vascular nevi can be divided into two classes: (1) non-radiation; (2) radiation therapy.

(1) *Non-radiation.*

(*a*) Freezing by solid carbon dioxide snow is the oldest method useful for small lesions, preferably on unexposed parts of the body.

(*b*) Surgical excision either with the scalpel or endotherm knife.

* Presented at a meeting of Society of Lebanon Hospital, January 13, 1942.

(*c*) Injection of sclerosing solutions, such as mixtures of quinine and ethyl carbamate, sodium morrhuate (5 per cent solution, etc.).

(2) *Radiation Treatment by Roentgen Rays or Radium.*

Radium has become the agent of choice in this country. It may be applied by various techniques, as moulds, flat applicators, or implantation of needles (interstitial method). I have always preferred surface applications in small doses at intervals. Ulceration of the nevus and secondary infection are no contraindication to radium therapy except that the doses should be smaller than for the non-infected type.

REPORT OF CASE

E. C., an infant, aged ten weeks, was referred to me, August 2, 1939, about twenty-eight months ago with the following history: Birth—full term, instrumental delivery, bottle-fed, no other children. At birth, a bluish-red irregular swelling was noticed over and in front of the right ear, extending over to the angle of the right side of the mouth, elevating and protruding the lobe of the right ear, making it more prominent than the left ear. Apparently not painful nor tender, and increasing in size. Local examination showed an irregularly outlined, multilobulated soft, compressible, bluish-red swelling in front of the right ear, in the region of the parotid gland extending partly into the external auditory canal posteriorly, and anteriorly involving the entire parotid area with irregular margins and extending along the right side of the face as far as the angle of the right side of the mouth almost to the margin of the lower lip. The ear appeared prominent and elevated somewhat by this swelling, which apparently was not painful nor tender.

The diagnosis was hemangioma of the right side of the face. Radium therapy was instituted on August 3, 1939. The technique consisted of dividing the entire involved region into five smaller areas, treating one to three areas at a time, with surface radium applicators, total at each treatment varying from 25 to 50 mg., with



Fig. 2. Four months after treatment.



Fig. 1. Before treatment, aged ten weeks.

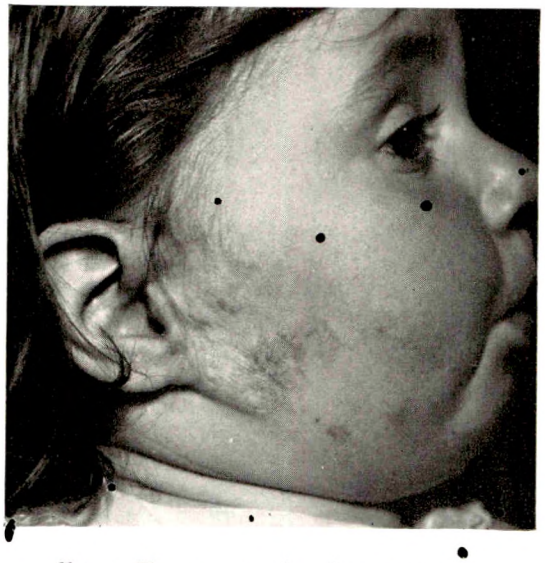


Fig. 3. Twenty months after treatment.

filtration of 1 mm. brass to 0.5 mm. platinum, at a distance of 0.25 cm. for one to two hours, dosage being from 25 to 37.5 mg-hr. At the beginning the intervals between treatments were three to four weeks and later the intervals were longer. From August 3, 1939, to April 17, 1941, a total of twenty-two radium applications was made to the entire lesion, with a total of 840 mg-hr. About six weeks from the commencement of treatment, there was visible evidence of diminution in swelling and change in color to a paler hue, which continued to improve slowly and gradually so that now there is present a soft whitish area over the site of the original lesion with scattered irregular spots of dilated capillaries. The area involved by this rather extensive lesion has shown a very remarkable improvement with shrinkage and replacement by a smooth, almost normal skin.

The case presented shows what can be accomplished with radium therapy, judiciously applied, by surface applications in small amounts, at intervals, over a prolonged period in the treatment of properly selected cases of vascular nevi in the skin of infants.

295 Central Park West,
New York, N. Y.

VOL. 49, NO. 6

ISODOSE CHARTS FOR FIELDS OF SPECIAL USEFULNESS IN THE TREATMENT OF CANCER OF THE UTERINE CERVIX

By SIDNEY M. SILVERSTONE, M.A., M.B., B.CH. (*Cambridge*), CARL B. BRAESTRUP, P.E., *and* BERNARD S. WOLF, M.D.

From the Radiotherapy Service of Dr. William Harris, The Mount Sinai Hospital
NEW YORK, NEW YORK

DURING a study of the distribution of radiation at various important points in the pelvis in the treatment of cancer of the cervix, detailed information was required concerning the amount of radiation at the periphery and outside a direct beam. When two beams of roentgen rays are employed close together as in a pelvic cycle, a knowledge of the amount of peripheral radiation is required in order to calculate doses in the region where the beams overlap. Depth dose tables[3,4] in the literature give doses only in the central axis of the beam. In articles[3,5] where isodose curves were published, it was usually not possible to interpret doses in the peripheral portion of the beam or in the region outside the direct beam with sufficient accuracy for our study. Arneson and Quimby[1] published isodose charts for the pelvis in which there was a separation of 2 cm. between adjacent parallel beams. Reinhard and Miers[6] published isodose curves for two adjacent oblique fields inclined at various angles towards each other. Apart from these and similar publications which, however, treat only of special cases of separation and angulation, the peripheral depth doses have not received the attention that their importance warrants. From the point of view of treating a malignant neoplasm, the doses at the periphery of a beam are equally as significant as the doses in the central axis. In order to obtain this information in sufficient detail, special studies were undertaken.

Two fields were studied. The first measured 10 by 15 cm. and was selected because it is the most frequent size used in a pelvic cycle. The second was a 15 by 15 cm. field, divided by a centrally placed lead strip 4 cm. wide, into two narrow fields, 5.5 by 15 cm. each. This divided field is a modification of a special pelvic field described by Tod and Meredith[7] for irradiation of the parametria in the treatment of cancer of the cervix. Its special usefulness lies in the fact that the midline structures of the pelvis, i.e., bladder, rectum and cervix, and the lateral structures of the pelvis, i.e., head and neck of the femur, are spared direct radiation.

It is well known that the depth dose depends upon the quality of radiation, target-surface distance, and size of field, as well as the atomic number, density and dimensions of the substance irradiated. What is not so well recognized is that the depth dose also depends upon the method of collimating the roentgen-ray beam. During our studies, we observed that if the roentgen-ray beam was collimated by means of a limiting diaphragm placed at the upper end of a cone, the depth dose in the peripheral region of the beam was considerably less than the dose in the central axis at the same level. When the method of collimation was altered by removal of the limiting diaphram and the use, instead, of a diaphragm only at the lower end of the cone where it is in contact with the phantom, the peripheral depth dose increased appreciably while the dose in the central axis remained practically unchanged. The problem of beam collimation and limiting diaphragms has been the subject of an earlier publication.[8] It is very likely that the variations in published isodose curves, especially with regard

* Presented at the Eastern Conference of Radiologists, New York, N. Y., Jan. 23–24, 1942.

to doses at the periphery of the beam, may have been occasioned, at least in part, by differences in methods of collimation.

EQUIPMENT

A Villard type generator was operated at 200 kv. (peak) and 20 ma. A filter of 0.75 mm. Cu. and 1.0 mm. Al was used in addition to the inherent filtration of the roentgen tube and tube head. The half-value layer measured 1.15 mm. Cu. The target-surface distance was 80 cm. The roentgen-ray beam was collimated at the surface of the phantom by means of a cone with lead-lined walls. No other limiting diaphragms were used.

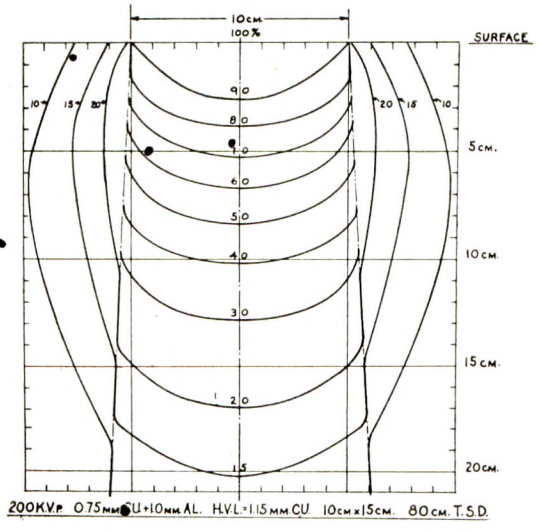


FIG. 1. Isodose chart for 10 by 15 cm. field. Backscatter: 36 per cent.

EXPERIMENTAL PROCEDURE

The depth dose measurements were made in a laminated "masonite" phantom, previously described by Braestrup and Blatz.[2] The phantom measured 30 by 30 cm. in area and 45 cm. in depth. Its density was unity. A thimble type ionization chamber was used, 0.72 cm. in diameter and 2.30 cm. long, permanently connected to an electrometer. The plane of measurement was taken through the central axis of the roentgen-ray beam and across the width of each field. In order to secure a nearly uniform dose distribution throughout the ionization chamber, its axis was placed at right angles to the plane of measurement. No readings were taken through the edges of the direct beam in the phantom. Instead, roentgenograms were made to determine the exact location of these edges at the various levels. Special precautions were taken to secure accurate alignment of the beam with respect to the phantom and the ionization chamber in order to avoid errors which even slight angulation might cause.

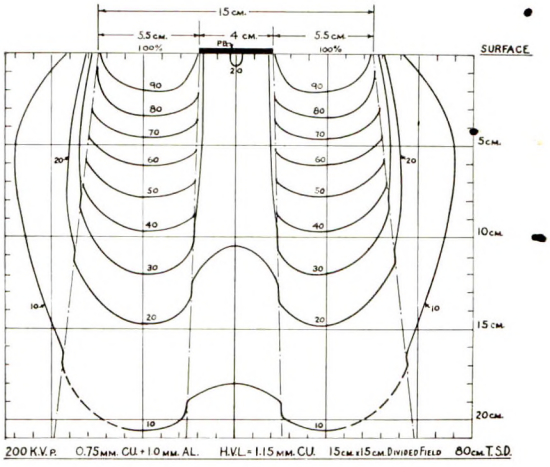


FIG. 2. Isodose chart for 15 by 15 cm. divided field. Backscatter: 31.5 per cent.

RESULTS

The results of these studies are indicated in the form of isodose curves. The backscatter factors were found to be:

10 by 15 cm. field.....	1.36	(36%)
5.5 by 15 cm. field.....	1.315	(31.5%)

The value for the divided field was higher than might be expected from such a narrow field. The increase was due to scattered radiation from the adjacent field.

DISCUSSION

It is quite evident that the beams are sharply defined in the phantom. The sharp gradients in the isodose curves coincide with the geometric outlines of the beam. The sharp definition of the beam in the phantom

is due largely to the method of collimation. Another factor, however, is that, in our experiments, measurements in the edge of the direct beam were purposely avoided. Such measurements would not reveal the true gradient of dose in this region but instead only an average of the intense radiation in the direct beam and the weak radiation outside the direct beam. Therefore such measurements would be misleading in the plotting of the isodose curves and would tend to obscure the sharpness of the gradient at the edge of the beam. This factor may also account for the smoothness of the isodose curves through the edges of the beam as noted in many publications. It is also of interest to note that, in the region outside the direct beam, the intensity of radiation depends upon the distance from the edge of the direct beam rather than the depth. The results for the 10 by 15 cm. field are in close agreement with the recently published isodose curves of Reinhard and Goltz.[5]

From the isodose curves for the 10 by 15 cm. field, the amount of radiation due to overlap from adjacent fields can be determined for any degree of separation or angulation.

The isodose curves for the 15 by 15 cm. divided field show that it is possible to obtain two narrow, sharply defined, divergent beams with the intervening region and the outer regions of relatively low intensity. The advantages of this arrangement are obvious where it is desired to deliver roentgen radiation only to the parametria in the pelvis when radium has been used to give a maximum dose to the cervix. The divided field method provides a greater degree of accuracy of set-up than is possible if each field were set up separately. There is also another advantage of greater economy since two fields are treated simultaneously.

The authors wish to acknowledge with thanks the technical assistance given by Charles J. Wurmfeld, P.E., in the construction of the isodose curves.

REFERENCES

1. Arneson, A. N., and Quimby, E. H. Distribution of roentgen radiation within the average female pelvis for different physical factors of irradiation. *Radiology*, 1935, *25*, 182–197.
2. Braestrup, C. B., and Blatz, I. H. Physical factors of low voltage "contact" roentgen therapy. *Radiology*, 1940, *35*, 198–205.
3. Quimby, E. H. Syllabus of Lectures. The Physical Basis of Radiation Therapy. Edwards Brothers, Inc., Ann Arbor, 1939, pp. 34 and 43.
4. Quimby, E. H., and Laurence, G. C. Radiological Society of North America Standardization Committee, Technical Bulletin No. 1. *Radiology*, 1940, *35*, 138–159.
5. Reinhard, M. C., and Goltz, H. L. Comparative isodose charts for 200 kv., 400 kv., and 1,000 kv. x-rays. *Radiology*, 1942, *38*, 74–76.
6. Reinhard, M. C., and Miers, F. Some factors influencing distribution of radiation using a two-oblique-field technic. *Radiology*, 1938, *30*, 633–635.
7. Tod, M. C., and Meredith, W. J. Dosage system for use in treatment of cancer of the uterine cervix. *Brit. J. Radiol.*, 1938, *11*, 809–823.
8. Silverstone, S. M., and Wolf, B. S. A study of the limiting draphragm method of collimation. *Radiology*, 1942, *39*, 314–319.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR

Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.

Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

AMERICAN ROENTGEN RAY SOCIETY

President: Ralph S. Bromer, Bryn Mawr, Pa.; *President-Elect,* Sherwood Moore, St. Louis, Mo.; *1st Vice-President:* C. G. Dyke, New York, N. Y.; *2nd Vice-President:* K. D. A. Allen, Denver, Colo.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J. *Historian:* Ramsay Spillman, New York, N. Y.

Executive Council: Ralph S. Bromer, Sherwood Moore, C. G. Dyke, K. D. A. Allen, H. Dabney Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, S. W. Donaldson, U. V. Portmann, M. C. Sosman, W. M. Doughty, J. C. Dickinson, C. H. Heacock, Bernard P. Widmann, Chairman, 250 South 18th St., Philadelphia, Pa.

Program Committee: B. P. Widmann, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., H. D. Kerr, Iowa City, Iowa, U. V. Portmann, Cleveland, Ohio, Lawrence Reynolds, Detroit, Mich., Sherwood Moore, Chairman, 510 S. Kingshighway, St. Louis, Mo.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., J. T. Case, Chicago, Ill., U. V. Portmann, Chairman, Cleveland, Ohio.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., V. W. Archer, University, Va., S. W. Donaldson, Chairman, Ann Arbor, Mich.

Representative on National Research Council: Karl Kornblum, Philadelphia, Pa.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-fourth Annual Meeting: 1943, cancelled.

AMERICAN RADIUM SOCIETY

President: William E. Costolow, Los Angeles, Calif.; *President-Elect:* Charles L. Martin, Dallas, Texas; *1st Vice-President:* Frank E. Adair, New York, N. Y.; *2nd Vice-President:* Eugene P. Pendergrass, Philadelphia, Pa.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo. (*Acting Secretary,* E. H. Skinner, 1532 Professional Bldg., Kansas City, Mo.); *Treasurer:* Leland R. Cowan, 606 Medical Arts Bldg., Salt Lake City, Utah.

Executive Committee: Lawrence A. Pomeroy, Chairman, Cleveland, Ohio, Frederick W. O'Brien, Boston, Mass., Hayes E. Martin, New York, N. Y.

Program Committee: Charles L. Martin, Chairman, Dallas, Texas, William S. MacComb, New York, N. Y., Eugene T. Leddy, Rochester, Minn., Herbert E. Schmitz, Chicago, Ill., John S. Bouslog, Denver, Colo.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: Ernst A. Pohle, Chairman, Madison, Wis., William H. Sargent, Oakland, Calif., Robert B. Taft, Charleston, S. C.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass., H. E. Martin, New York, N. Y.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., B. P. Widmann, Philadelphia, Pa., F. W. O'Brien, Boston, Mass.

Twenty-eighth Annual Meeting: 1943, cancelled.

Vol. 49, No. 6

EDITORIAL

CALCIFIED PULMONARY LESIONS

SINCE the comprehensive report of Sayers and Meriwether[1] on miliary lung disease due to unknown cause, numerous reports have appeared dealing with this subject. Sayers and Meriwether made their original report as a result of the examination of several thousand individuals in the mines in and around Picher, Oklahoma, and of the subjects with whom they were dealing 90 per cent were born in Missouri, Oklahoma, Kansas, Arkansas and Illinois, and the majority came from rural districts or had spent several summers in the harvest fields.

More recently an article by Olson, Wright and Nolan[2] calls attention to an epidemiological study of calcified pulmonary lesions in an Ohio county. It had been noted previously that there is a high prevalence of pulmonary calcification in certain areas of the United States, and some observers, notably Gass and his co-workers, and Lumsden and Dearing, have pointed out that such calcifications are common in or adjacent to the Appalachian Plateau.

Prior to the report of Sayers and Meriwether the presence of miliary-like calcifications in the lung fields was interpreted as evidence of primary or first infection tuberculosis but of the 125 cases of "typical miliary lung disease" found in their study, tubercle bacilli were present in only 2 of 88 cases in which examination of the sputum was made. They believed that the presence of miliary calcification in the lung fields did not necessarily justify the conclusion that the patient had had miliary tuberculosis with subsequent healing of the lesions but that the condition might be due to some other cause, possibly to a fungous infection.

Gass and his co-workers, and Lumsden and Dearing, found from their studies that approximately half of the young individuals whom they studied with pulmonary calcifications were tuberculin negative.

These observations have aroused considerable interest and also considerable controversy and it has been shown from studies of various investigators, notably Lumsden and Dearing, that there are great differences in the prevalence of pulmonary calcification in different states and that these variations not only occur in different states but sometimes also in closely adjacent counties of the same state. It was observed that this geographic distribution in pulmonary calcification was associated closely with the occurrence of limestone and chert formations.

In an attempt to clarify some of the observations, Olson, Wright and Nolan set about to determine the relationship between the presence of pulmonary calcification and exposure to tuberculosis, ascariasis, and other specific diseases. They were particularly interested in the study of the relationship of *Ascaris* infection to pulmonary calcification. The selection of the area for this study was Ross County, Ohio, as this county seemed to fulfill the basic requisites for study, namely it was located adjacent to the Appalachian Plateau, an area in which pulmonary calcification was of common occurrence and where tuberculosis mortality was not unusually high. Another factor that determined the selection of this county was that the geology of this particular section was known.

[1] Sayers, R. R., and Meriwether, F. V. Miliary lung disease due to unknown cause. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 337–351.

[2] Olson, B. J., Wright, W. H., and Nolan, M. O. Epidemiological study of calcified pulmonary lesions in an Ohio county. *Pub. Health Rep.*, 1934, *56*, 2105–2126.

Olson, Wright and Nolan, statistically analyzing the data from their survey [illegible] to the conclusion that no significa[illegible]lationship could be demonstrated betwe[illegible] contact with known tuberculosis and the occurrence of pulmonary calcification in the group studied, and that this presence of pulmonary calcification as observed in their study had little demonstrable relationship to tuberculosis.

In a further attempt to elucidate the cause of pulmonary calcifications in the absence of a positive tuberculin test or a history of tuberculosis, they considered the possible rôle of parasites in the production of pulmonary calcification since it had been noted that there was a rather close correlation between the distribution of such calcification and the areas of high incidence of *Ascaris lumbricoides* in man. In general, the distribution of pulmonary calcification in the southeastern United States corresponds closely to the area of high *Ascaris* incidence in the Appalachian Plateau and its foothills, the area referred to by Otto and Cort as the endemic center of *Ascaris*.

It has been demonstrated many times by parasitologists that the death of adult worms and the arrestment of parasite larvae in parenchymatous tissues are frequently followed by the production of a granulomatous type of lesion grossly and sometimes microscopically indistinguishable from lesions of this type which characterize certain bacterial diseases.

Shortly after the discovery of the life cycle of *Ascaris lumbricoides* by Stewart, Ransom pointed out the acute manifestations connected with the migrations of *Ascaris* larvae through the lungs of susceptible animals and noted that the same problem should be carefully investigated in human infections. As a result many studies have been carried out in the hope of establishing this point.

In an attempt to throw some light on this subject, Olson, Wright and Nolan carried out extensive soil examinations in the areas where calcification of the lung [illegible]evalent. They came to the conclusion [illegible]at on the basis of the data furnished by their epidemiological study they were unable either to prove or disprove the possible rôle of *Ascaris* as a causative agent in pulmonary calcification. They believe, however, that until additional evidence is available the parasite in question should not be ruled out as a possible etiological agent in pulmonary calcification.

A further article[3] on the subject of miliary calcification of the lung appears in this issue of the JOURNAL. The miliary lesions in the two cases reported were discovered incidentally in routine examinations of the chest; both cases were studied clinically, bacteriologically and pathologically. The cause of the pulmonary lesions could not be definitely ascribed to disease other than tuberculosis, and taking the findings of the complete study into account, it was believed that the cause for the pulmonary appearance in the two cases was tuberculosis, probably of the primary type. Geever concludes that although the possibility exists that other agents may cause this interesting lung picture, the importance of tuberculosis should not be minimized. He includes an outline of the studies which should be performed whenever an opportunity presents itself to examine a patient who demonstrates the finding of pulmonary calcification in the chest roentgenogram.

It thus appears from the combined studies of various observers that there is in certain areas and states a high incidence of pulmonary calcification which cannot be definitely related to tuberculosis as a causative factor, that these pulmonary calcifications result from an as yet unrecognized disease of very common occurrence which produces pulmonary lesions closely resembling the roentgen appearance of primary tuberculosis, and it is their considered opinion that the finding of pulmonary cal-

[3] Geever, E. F. Miliary calcification of the lung. AM. J. ROENTGENOL. & RAD. THERAPY, June, 1943; *49*, 777-782.

cification, particularly in tuberculin-negative individuals, should not necessarily be assumed to be evidence of infection with the tubercle bacillus. By other observers it is believed that while various causative agents must be taken into account, the importance of tuberculosis should not be minimized.

The many studies carried out on the cause of pulmonary calcification have added greatly to our knowledge of the condition, but in view of their inconclusive nature, further comprehensive studies should be undertaken to establish if possible the definite etiological agent or agents.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Chicago, Ill., June 6, 1943.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

Arkansas Radiological Society
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 29–Dec. 3, 1943.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Lt. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

Florida Radiological Society
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

*Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Herman Klapproth, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

CANCER TEACHING DAY

A Cancer Teaching Day, arranged by a number of the medical societies of Utica and of the State of New York, was held at the Hotel Utica, Utica, New York, on June 17, 1943. The program of the afternoon meeting, which was called to order at 4.00 P.M. with Dr. Bradford F. Golly, President of the Medical Society of the County of Oneida, as Chairman, was as follows:

The Management of the Patient with Advanced Cancer. Norman Treves, M.D., New York, N. Y.

Cancer of the Larynx, Bronchi, and Esophagus (illustrated by motion pictures and lantern slides). Chevalier L. Jackson, M.D., Philadelphia, Pa.

Dinner was served at 6.15 P.M., after which the meeting was resumed at 7.30 P.M. with Dr. Bradford F. Golly as Chairman, and the following two papers were presented:

Cancer of the Colon and Rectum. George E. Binkley, M.D., New York, N.Y.

The Significance of Enlarged Lymph Nodes. Lloyd F. Craver, M.D., New York, N.Y.

CAPTAIN ALBERT SOILAND HONORED

On Wednesday, May 5, 1943, the Radiological Section of the Los Angeles County Medical Association celebrated the seventieth birthday of Captain Albert Soiland, M.C., U.S.N.R., with a testimonial dinner at the University Club. About one hundred and fifty of Captain Soiland's friends were present, including Rear Admiral Ralston Holmes, U.S.N., Captain W. H. Michael, M.C., U.S.N., The Honorable Fletcher Bowron, Mayor of Los Angeles, The Honorable Erling S. Bent, Norwegian Consul, Captain Iverson, U.S.N., Captain John Ruddock, M.C., U.S.N.R., Captain Walters, U.S.N., and Captain William E. Costolow, M.C., U.S.N.R.

Congratulatory messages were received from the Crown Prince and Princess of Norway, the Norwegian Ambassador to the United States, Admiral Chester W. Nimitz, CINPAC, Rear Admiral Ross McIntyre, Surgeon General of the United States Navy, Admiral William D. Leahy, Chief of Staff to the President, and many others.

Following a pleasant program of entertainment the principal address of the evening was given by Commander John D. Camp, M.C., U.S.N.R., whose subject was "The Origin and Development of the Science of Roentgenology."

Dr. Soiland was presented with an engrossed scroll bearing the signatures of all those present to which he replied with words of appreciation. As the culmination of the evening Captain W. H. Michael, M.C., U.S.N., presented the fourth gold stripe elevating Dr. Soiland from the rank of Commander to the rank of Captain in the United States Navy.

DR. KIRKLIN APPOINTED X-RAY CONSULTANT

Dr. B. R. Kirklin of the Mayo Clinic, Rochester, Minnesota, has been appointed as X-Ray Consultant in the Office of the Surgeon General of the Army, with the rank of Colonel.

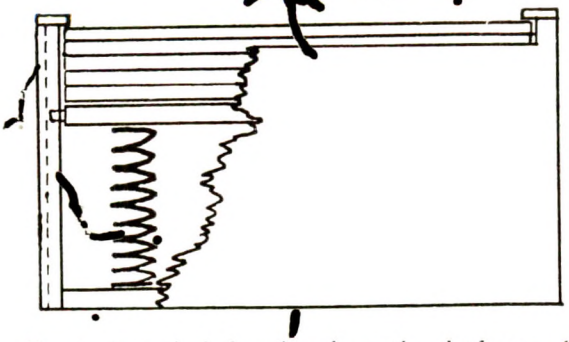


FIG. 2. A vertical elevation shows the platform and one supporting spring. Five cassettes are shown in place.

anesthetized during the administration of the radiopaque substance and the exposure of the films. The child is placed on a low canvas frame, supported by four legs which rest on the table top, as shown in Figure 1. The cassette changer is placed beneath the canvas frame and fastened to the table top with suitable straps. The height of the frame should just clear the top of the cassette holder. The patient may be placed in any desired position, but we have found that in general the left anterior oblique is most satisfactory. Because the roentgen rays will penetrate the top cassette, it is necessary to back each cassette with lead foil, so that the rays reach only one film at a time. We have found that 1/64 inch foil is sufficient protection for the following factors: 76 kv., 400 ma., and 1/60 second at 40 inches, but if a heavier exposure is contemplated, it might be wise to use double the thickness. The foil is cut to size and a piece fastened on the back of each cassette with adhesive tape.

In angiocardiography we have employed 20 cc. of 75 per cent diodrast and a needle that is large enough to allow the injection to be completed in about two seconds. As the plunger meets the bottom of the syringe, a signal is given and the first exposure is made. The top cassette is then pushed out of the holder by an assistant and retrieved on the opposite side of the table by a second assistant who places the cassette on a convenient chair or stool. The second cassette rises into position and the next exposure is made and the process repeated until all films contained in the box have been exposed. When a large cone is used with the tube we have not found sufficient scattered radiation to fog any of the exposed film. It is important that each assistant wear a protecting apron as some exposure to scattered radiation is unavoidable.

In a series of twelve angiocardiograms we have found the method very convenient and satisfactory, and with a little practice it is possible to make one exposure every second.

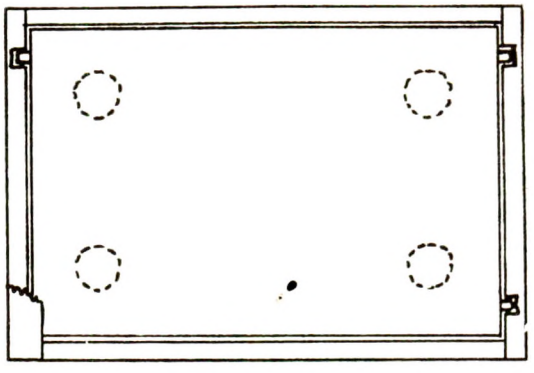


FIG. 3. Horizontal section shows the position of the four springs beneath the platform and also the flanges and grooves at either end of the platform.

No. 6

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

AN INEXPENSIVE CASSETTE CHANGER FOR ANGIOCARDIOGRAPHY

By EDWARD B. D. NEUHAUSER, M.D., *and* CHARLES G. JENNINGS, M.D.
From the Department of Roentgenology of The Infants' Hospital and The Children's Hospital
BOSTON, MASSACHUSETTS

ANGIOCARDIOGRAPHY or the visualization of the great vessels and the cardiac chambers by roentgen examination after the injection of a radiopaque substance into the venous system is now a well recognized accessory method of study of abnormalities of the cardiovascular system. There is only one part of the examination that presents any considerable difficulty, and that is the rapid exposure of the six to eight films in as many seconds, without which the examination is apt to prove of little value. There are several adequate methods available for procuring such a series of roentgenograms, but for those roentgenologists who only occasionally perform this type of examination, the equipment is either too expensive or too bulky when so infrequently used.

To meet this objection, we have designed a small, inexpensive and effective semi-automatic cassette changer. The apparatus was made in a few hours by the Hospital carpenter at a total cost of two dollars and fifty cents. Basically, this cassette changer is an open-topped box, sufficiently large to accommodate eight 11 by 14 in. cassettes without any unnecessary free play at either side or end. The bottom cassette rests on a platform which is supported by four ordinary bed springs which should be strong strong enough to raise a weight of 60 pounds. When the cassette changer is loaded the platform is depressed with resulting compression of the springs. With the pressure being exerted by the springs, the platform with the superimposed cassettes tends to rise until the top cassette is stopped by a small flange at either end of the container box. To procure an even rise of the platform each end of the platform has two small projections that fit into grooves in the end pieces of the box.

All of our angiocardiography has been done with children and we have found that it is more satisfactory to have the patient

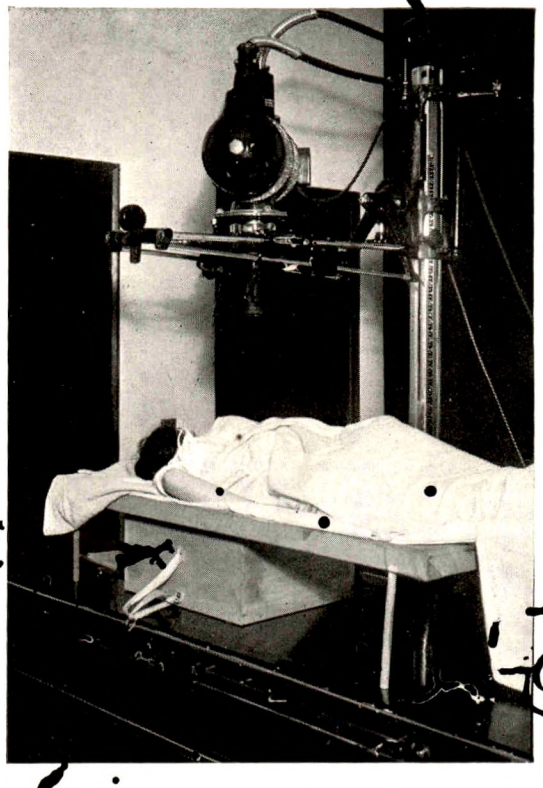


FIG. 1. Shows the cassette changer in place and strapped to the table beneath the canvas frame which supports the patient clear of the box.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Gynecology and Obstetrics

HARPER, R. A. K.: Congenital duodenal obstruction 832

OGILVIE, R. F.: Duodenal diverticula and their complications 832

FELDMAN, M.: Roentgenologic consideration of normal mucosa of duodenum 832

PORTIS, S. A.: Clinical significance of roentgenologic findings of small intestine 833

RIGLER, L. G.: Spontaneous pneumoperitoneum 833

ALTMAN, W. S.: Cholangiography, fractional method 833

DIPPEL, A. L., and DELFS, E.: Accuracy of roentgen estimates of pelvic and fetal diameters 834

FROSTBERG, N.: Case of tympany of uterus diagnosed by roentgen examination 834

TORPIN, R., and HOLMES, L. P.: Roentgen diagnosis of intra-uterine hydrocephalus ... 834

Genitourinary System

CAHILL, G. F.: Tumors of adrenal and use of air insufflation in their diagnosis 835

KIRWIN, T. J.: Papillary carcinoma of renal pelvis 835

STIRLING, W. C., and ASH, J. E.: Papillary adenocarcinoma of kidney 835

HUGGINS, C., STEVENS, R. E., JR., and HODGES, C. V.: Studies on prostatic cancer 836

KAUFMANN, W., and WRIGHT, A. W.: Lymphosarcoma of prostate gland 836

PRINCE, C. L., and VEST, S. A.: Leiomyosarcoma of prostate 836

BARRINGER, B. S., and EARL, D.: Teratoma testis 837

FINESTONE, E. O.: Urinary extravasation (periurethral phlegmon) 837

GRAVES, R. C., and GUISS, L. W.: Tumors of urethra 837

Nervous System

HAMBY, W. B.: Misplaced spinal lipiodol 838

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GYNECOLOGY AND OBSTETRICS

HARPER, R. A. K. Congenital duodenal obstruction. *Brit. J. Radiol.*, Nov., 1941, *14*, 360–363.

Congenital obstruction of the duodenum is very rare and is generally diagnosed in early infancy. A case is described which is unusual from the fact that the obstruction did not cause serious enough results to necessitate examination until the patient was twenty years old. He had always had a feeling of distention of the abdomen after eating and had vomited almost daily all his life. When he came for examination his abdomen was distended. Roentgen examination showed fluid levels in the upper abdomen. There was marked distention of both stomach and duodenum and fluid levels in the duodenum. The obstruction was at the duodenojejunal flexure and very little barium left the duodenum in the first five hours. The examination also showed non-rotation of the cecum.

Gastrojejunostomy was performed and the patient made an uneventful recovery. The obstruction was probably due to fixation of the duodenojejunal flexure during the development of the intestine.

Obstruction of the duodenum is frequently associated with other congenital anomalies and in this case the patient showed cleft palate and non-rotation of the cecum.—*Audrey G. Morgan.*

OGILVIE, ROBERTSON F. Duodenal diverticula and their complications with particular reference to acute pancreatic necrosis. *Brit. J. Surg.*, Jan., 1941, *28*, 362–379.

Duodenal diverticula are found quite frequently on postmortem examination and were formerly considered anatomical curiosities. Case in 1916 first demonstrated one during life by roentgen examination and since then they have been excised by a number of surgeons. As late as 1939 Edwards in his book on "Diverticula and Diverticulitis of the Intestine" says that the association of pancreatitis with diverticula of the second part of the duodenum is vague and usually accidental.

In this article 4 cases of perivaterine diverticulum are described which refute this idea. In the first case there was obstruction and dilatation of the pancreatic duct and common and accessory cystic bile ducts as well as the gallbladder. This had resulted in atrophy of the pancreas. The patient died of obstructive jaundice. In all of the other 3 cases the diverticulum was associated with acute necrosis of the pancreas. There is evidence that in the majority of cases necrosis of the pancreas is caused by obstruction of the ducts. This does not always occur, however, as shown by Case 1, and it is probable that the occurrence of necrosis is dependent on the degree of secretory activity of the glands. In experimental work ligation of the pancreatic duct produced necrosis only when performed during digestion.

Other complications of duodenal diverticula are diverticulitis, which may result in inflammation of surrounding tissues. Diverticulitis of duodenal diverticula is rare, however, as they drain freely into the intestine. The diverticula may contain enteroliths or gallstones. Only 1 case of carcinoma of a duodenal diverticulum has been reported in the literature.—*Audrey G. Morgan.*

FELDMAN, MAURICE. A roentgenologic consideration of the normal mucosa of the duodenum. *Radiology*. Sept., 1941, *37*, 284–288.

A careful study of the mucosa of the duodenum is important as it helps to define the roentgen appearance of beginning disease of the duodenum. Heretofore early changes in the second portion of the duodenum have been overlooked or misinterpreted frequently.

The author presents a detailed roentgen study of the descending portion of the duodenum which is particularly interesting because of its relation to the head of the pancreas and the biliary and pancreatic ducts. The findings are described in detail and illustrated with roentgenograms. The union of the two ducts forming the papilla of Vater can be seen. There is a circular hood-like fold surrounding the papilla at the lower end of the plica longitudinalis. Some of the transverse or Kerkring's folds pass over

tl e long tudinal fold while others end at it. The normal minor papilla cannot be seen in the roentgenogram. The relation of the head of the pancreas to the common and pancreatic ducts and the major papilla is shown.—*Audrey G. Morgan.*

POLTIS, SIDNEY A. The clinical significance of the roentgenologic findings of the small intestine. *Radiology*, Sept., 1941, *37*, 289–294.

The author mentions some significant findings in the small intestine such as the association of rapid motility shown by roentgen examination with achlorhydria and segmentation of the small intestine with corresponding dilatation of the individual coils or groups of coils in vitamin B deficiency. The mucosal pattern may be distorted and emptying time delayed. Vitamin A disturbance of the small intestine may be confused with the clinical picture of idiopathic steatorrhea. In idiopathic steatorrhea the valvulae conniventes may be obliterated to such an extent that the bowel may look like a tube through which wax has been poured and allowed to harden. There may also be dilatation of the lumen and spasm with sausage formation or segmentation. He describes the roentgen findings in a case of Hodgkin's disease of the upper jejunum.

Though roentgen examination of the small intestine is of great importance there seems at present to be no definite standardization of roentgen technique for such examination. Attempts are being made to standardize the technique by experimenting with small and large meals and adding various non-irritating drugs which delay motility. Because of the complexities of metabolism and digestion in the small intestine it will probably never be possible to demonstrate definite patterns in the mucosa corresponding to different diseases but definite conclusions in regard to pathognomonic roentgen findings will only be arrived at by correlating the clinical symptoms with repeated roentgen examinations.—*Audrey G. Morgan.*

RIGLER, LEO G. Spontaneous pneumoperitoneum: A roentgenologic sign found in the supine position. *Radiology*, Nov., 1941, *37*, 604–607.

Diagnosis of rupture of the stomach, small or large intestine can be confirmed by roentgen examination. It has heretofore been necessary to make the examination with the patient standing so that the gas might collect beneath the diaphragm. But now it has been found that there is a sign that can be seen in the ordinary preliminary roentgenogram of the abdomen with the patient lying down. In such roentgenograms if there is air in the peritoneal cavity the outer as well as the inner wall of the bowel can be seen. Gas passes between the adjacent loops of intestine so that the outer wall of each loop can be seen. This sign occurs only in pneumoperitoneum.

Therefore frequent roentgenograms should be taken in cases of obstruction of the intestine under observation. With such films it may be possible to detect perforation before there are any clinical signs.—*Audrey G. Morgan.*

ALTMAN, W. S. Cholangiography, fractional method. *Radiology*, Sept., 1941, *37*, 261–268.

Cholangiography is used almost as a matter of routine in cases of biliary surgery at Beth Israel Hospital, Boston. In the fractional method the first films are taken in the operating room, using 80-90 kv., 30 in. distance and 60 ma-sec. Most patients are given spinal anesthesia so that respiration can be suspended voluntarily during operation. The cystic duct is exposed and a small ureteral catheter introduced into it. Bile is aspirated through the catheter and examined. Then 3 to 5 cc. diodrast is injected into the duct. A single film is then taken, a larger amount of diodrast (8–10 c.c.) injected and a second film taken. These films are examined and interpreted during the operation. If there are no indications for exploration of the common duct no further films are necessary. If the common duct is to be examined another check-up film is taken before the abdomen is closed.

Postoperative cholangiography is done in the roentgen department. Bile is aspirated and about 4 cc. diodrast injected. If it is advisable to flush the tube with saline previous to the installation of the contrast medium larger amounts are injected (6 to 10 cc.) and stereoscopic films are taken. Then the patient inhales amyl nitrite, 4 to 5 cc. more injected and a fourth film taken. The amyl nitrite relaxes Oddi's sphincter, giving better visualization of the intramural part of the ampulla.

The fractional method has proved of value in diagnosis where there was difficulty in interpreting a single film an account of motion caused by breathing, spill or leakage around the catheter or T-tube, or bubbles, kinks in the cystic

or common ducts, overlapping bone shadows, superimposition of the cystic duct on the common duct, superimposed instruments, catheters or T-tubes, anomalies or artifacts.

The author discusses 109 cases in which he used the method. There was only one death, a mortality of less tham 1 per cent. This patient was a man of seventy with a partially gangrenous gallbladder who died three days after operation of acute kidney failure. The method therefore certainly involves no added risk.—*Audrey G. Morgan.*

Dippel, A. Louis, and Delfs, E. The accuracy of roentgen estimates of pelvic and fetal diameters. *Surg., Gynec. & Obst.*, May, 1941, *72*, 915–922.

Modern roentgen pelvimetry and fetometry have been developed greatly during the past few years and are now in use by many hospitals and teaching institutions. Many obstetricians do not use them, however, because they are not convinced of their precision.

The authors therefore try to evaluate the accuracy of several roentgen methods commonly used for these measurements. The simplest method is that of Thoms' inlet view but it is accurate only when the external bony landmarks are properly selected. There is a considerable degree of variation in the pelvis in different individuals and sometimes the plane of the pelvic inlet cannot be accurately located, even from these bony landmarks.

It has been claimed that roentgenograms taken from a distance of 6 feet are not distorted but the authors show by means of similar triangles that teleroentgenograms are not accurate; fetal and pelvic measurements are overestimated from them by about 10 per cent.

In stereoscopic films markers must be used and it is necessary to use the exact tube-film and tube-shift distances called for by the technique in use. Hodges' laboratory has a precision roentgen machine in which the tube-film and tube-shift distances have been calibrated and they cannot be altered. But most laboratories do not have such machines and the authors give the mathematical methods for making precise estimates from stereoscopic films taken by a non-precision roentgen machine. They have found the Hodges graphic, the precision and the stereoroentgenographic methods about equally accurate in estimating maternal pelvic and fetal measurements. The Thoms and Hodges lateral methods of measuring the anteroposterior diameters of the pelvis are quite accurate but with the former the lead ruler must be placed accurately in the median plane of the pelvis for correct results. Both of these methods are apt to fail of absolute accuracy in asymmetrical pelves. A table is given showing the roentgen estimate of the obstetrical conjugate in 6 cases by the various methods as compared with the direct measurement of museum specimens of pelves or of patients on laparotomy.—*Audrey G. Morgan.*

Frostberg, Nils. Fall von Röntgendiagnostizierter Tympania uteri. (Case of tympany of the uterus diagnosed by roentgen examination.) *Acta radiol.*, 1941, *22*, 387–392.

A case is described in a primipara thirty-four years of age admitted to the hospital on March 9, 1940. In 1936 she had been treated for myoma of the uterus and cyst of the left ovary. On this admission she had rapid pulse, temperature 37.6° C., distended abdomen and great difficulty in urination. The head of a fetus, evidently dead for some time, as it showed maceration of the third degree, lay in front of the vulva.

Roentgen examination was made, chiefly to determine whether the patient had peritonitis. It showed the uterus greatly distended with gas; the fetus, placenta and umbilical cord could be seen plainly in it. No peritonitis. As soon as the fetus was delivered the umbilical cord ruptured and a large amount of vile-smelling gas was discharged. The cord was only 23 cm. long. With the discharge of the gas the abdomen collapsed. In spite of blood transfusion the patient died that evening. The labor complication was probably caused by the short cord and the high position of the placenta. Autopsy showed necrotic, gas-filled foci in the spleen and kidneys. Microscopic examination showed short chains of bacilli, probably Welch bacilli. In delayed labor with infected amniotic fluid gas in the uterine cavity can be demonstrated by roentgen examination.—*Audrey G. Morgan.*

Torpin, Richard, and Holmes, L. P. Roentgen diagnosis of intra-uterine hydrocephalus. *Radiology*. Sept., 1941, *37*, 351–352.

A case of roentgen diagnosis of intrauterine hydrocephalus is described. The lateral soft tissue method was used supplemented by study of the obstructed labor by the grid method in which the roentgen pelvimeter devised at the University Hospital of Georgia was used. This

gives an 8×10 inch film showing the fetal head framed in the inlet.

The lateral film showed the skeleton of a fairly large fetus without spina bifida but with a very large head. The height of the fundus was 4 cm. greater than the average indicating a large head. The head was hard and measured through the abdominal wall 14 cm. in transverse diameter Though it was not certain which diameter this was it indicated a large head. After Twenty-four hours of fairly hard labor and twenty hours after the rupture of the membranes the fetus was delivered by low cesarean section. The child weighed 9 pounds, 8 ounces but had the body of about an 8 pound normal infant. The head was relatively too large for the body and showed the bulging forehead and deep-set eyes of typical hydrocephalus. Tracings from roentgenograms are given of the skull of a normal fetus, those of the hydrocephalic child and those of a giant fetus recently seen, and a table is given showing the comparative measurements of the three.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

CAHILL, GEORGE F. Tumors of the adrenal and the use of air insufflation in their diagnosis. *Radiology*, Nov., 1941, *37*, 533–544.

In 1921 Cahill first described a method of diagnosis in adrenal conditions which consisted of introducing air into the perirenal fascial planes. This outlined the kidneys and adrenals more clearly than ordinary roentgenography. The author has used it in several hundred cases since 1930 without any bad results and with distinct advantage in diagnosing tumors of the adrenal. He gives a classification of tumors of the adrenal and discusses the use of the method in the different classes, illustrating them with roentgenograms.

Dr. Joelson said in the discussion that while Dr. Cahill had been so successful with the use of this method in such a large series of cases the method is not entirely free of danger. In a smaller series of cases at Lakeside Hospital they had had no fatalities but in several cases there were symptoms due no doubt to air embolism. In a fair percentage of cases tumors of the adrenal can be demonstrated on ordinary films. They have recently had 4 cases in which the demonstration was made in this way.

Dr. Cahill replied that in the injection of air into the perirenal fascial planes there is some danger of air embolism but that if care is taken the danger is slight and more than outweighed by the value of the films. There is more danger in large tumors with tortuous, thin-walled vessels and the method is not recommended in these cases. It is most useful in the diagnosis of small tumors that cannot be demonstrated in any other way. As there is danger in surgical exploration in these cases the patients should be given the advantage of this method to determine the side on which the tumor is located. The amount of air used depends on the size of the patient and the type of tumor. Patients with edema and fat deposits require more air for the demonstration of the tumor than thin ones. —*Audrey G. Morgan.*

KIRWIN, THOMAS J. Papillary carcinoma of the renal pelvis; diagnosis and treatment. *Surg., Gynec. & Obst.*, Dec., 1941, *73*, 759–765.

Papillary carcinoma of the renal pelvis comprises approximately 5 per cent of all renal tumors. Hematuria is the only early sign and should always be thoroughly investigated by every possible clinical and roentgenological procedure until a diagnosis is established. The retrograde or excretory pyelograms may show filling defects, deformity of calices and evidence of obstruction. Aspiration of material through the ureteral catheter will sometimes result in histopathological evidence of malignancy. Treatment is surgical and should include nephrectomy and ureterectomy because of the known tendency for transplants to occur in the ureter and bladder.

A case report is included.—*G. W. Chamberlin.*

STIRLING, W. CALHOUN, and ASH, J. E. Papillary adenocarcinoma of the kidney; hypernephroid tumors. *Surg., Gynec. & Obst.*, Sept., 1941, *73*, 305–311.

Exclusive of the tumors of the renal pelvis, Wilms' tumor, and tumors of the renal blastema, the tumors of the kidney are adenoma, adenocarcinoma, papillary adenocarcinoma with clear and granular cells.

The origin of papillary adenocarcinoma is not yet certain. True hypernephroma may occur, but many facts point to the renal origin of these tumors. The most important point in the argument against the adrenal origin of these tumors is the lack of the secretion of cortin by the cells of these tumors.

Papillary adenocarcinoma is the most common tumor of the kidney in adults. It may develop slowly and become massive before it

letected. Different portions show different gross appearances. Some areas may be yellow, others red. Calcification or cystic degeneration may occur. The tumor tends to grow into the renal pelvis and vein. The lungs and bones are the most common sites of metastasis. Early diagnosis is necessary. Symptoms are frequently absent or scarce. Hematuria, in large or small amount, should always be investigated. A large mass in the loin is usually a late manifestation.

The study of a suspected renal tumor should include a primary intravenous urogram to determine the comparative size, function, and appearance of the calices and pelves. Cystoscopic examination with bilateral pyelograms should follow. Too much reliance should not be placed on a single negative pyelogram because the lesion may be obscured by the dye. Intravenous urography with multiple films is sometimes more satisfactory than retrograde studies.

The authors recommend preoperative radiation therapy for those patients who give a short history and have a fixed mass. Metastases should be searched for before operation. In large tumors, the transperitoneal approach offers better exposure for early clamping of the renal pedicle.—*G. W. Chamberlin.*

HUGGINS, CHARLES, STEVENS, R. E., JR., and HODGES, CLARENCE V. Studies on prostatic cancer. II. The effects of castration on advanced carcinoma of the prostate gland. *Arch. Surg.*, Aug., 1941, *43*, 209–223.

Twenty-one patients with demonstrable metastases or local extension of the prostatic cancer outside the capsule of the prostate were treated by orchidectomy. Fifteen had roentgenologically demonstrable metastases in the pelvis or spine. Most had osteolytic and osteoblastic metastases and 1 had a pathological fracture of the pelvis.

The acid phosphatase, in 8 cases in which malignant tissue was available, was comparable to that found in the normal adult prostate and much greater than in the newborn infant. This suggests that the cells of the prostatic malignancy are of adult epithelium.

In patients with carcinoma of the prostate who had marked elevation of the serum acid phosphatase, castration caused a reduction toward normal which was maintained for many months.

Eighteen of the 21 patients showed clinical improvement following orchidectomy. There was relief of pain, gain in weight, and an upward trend of the erythrocyte count.

In all cases, except 1, the prostate gland decreased to a small size, and in many cases, it became soft and so small that it could scarcely be palpated.

In all cases in which metastases to bone were present, increased osteosclerosis occurred within three to six months. The 1 case of pathological fracture became united.

Untoward results of castration were temporary swelling of the ankles, development of hot flashes, and the abolition of sexual capacity. The hot flashes could be eliminated by using estrogenic substance.—*G. W. Chamberlin.*

KAUFMANN, WILLIAM, and WRIGHT, ARTHUR W. Lymphosarcoma of the prostate gland. *Arch. Surg.*, Dec., 1941, *43*, 1061–1075.

This article consists of a review of the literature and a detailed case report of primary lymphosarcoma of the prostate. Justification for this presentation lies in the controversial opinions regarding the possibility of such a primary lesion. The case reported tends to support the author's contention that primary lymphosarcoma of the prostate does occur. It is a rapidly growing neoplasm which infiltrates the surrounding tissues. It may arise from preexisting lymphoid tissue or from tissue formed as a result of previous chronic inflammation. The tumor is resistant to radiation therapy. Extreme care must be exercised to differentiate this tumor histopathologically and clinically from anaplastic carcinoma of the prostate.—*G. W. Chamberlin.*

PRINCE, C. L., and VEST, S. A. Leiomyosarcoma of the prostate; report of a case and critical review. *J. Urol.*, Dec., 1941, *46*, 1129–1143.

Leiomyosarcomas differ from leiomyoma histopathologically in the following findings: increased cellular pleomorphism, hyperchromatic nuclei, mitotic figures, decreased acidophilic character of the cytoplasm and invasion of contiguous structures. Their occurrence in the prostate is unusual.

The authors report a case in a man, age fifty-two, who was admitted with complaint of dysuria, frequency, and hematuria of two years' duration. The prostate was hard, enlarged and asymmetrical. A biopsy obtained with the McCarthy resectoscope showed [illegible] myosarcoma. No evidence of metastasis could

be found. Due to the radioresistance of muscle tumors a radical perineal prostatectomy was performed. Examination one year after operation showed no local recurrence and no evidence of any metastatic lesion.

The authors found a great deal of confusion in the literature on prostatic sarcomas. Some authors denied the existence of muscle cell tumors of the prostate. The authors of this paper found 15 cases in the literature of leiomyosarcoma of the prostate and they have summarized their main features in tabular form.

The etiology of this tumor is obscure; the symptoms are those of prostatic obstruction, and the diagnosis is usually made only on biopsy. Metastases were present in 40 per cent of cases. Local extension occurred in 85 per cent of the cases. The prognosis is poor. The only hope for cure is radical perineal prostatectomy. The tumors are too radioresistant for cure by irradiation.

From their studies the authors conclude that this type of sarcoma is the least malignant prostatic sarcoma in the adult. They feel that it is important to try to make a differential diagnosis in prostatic sarcomas for this reason.—*R. M. Harvey.*

Barringer, Benjamin S., and Earl, David. Teratoma testis. *Surg., Gynec. & Obst.*, March, 1941, *72*, 591–600.

This article is a survey of general information obtained from a group of 37 patients with teratoma testis who came to autopsy.

The majority of cases in this series had either surgical or radiation treatment. The average age of the patients studied was 31.5 years. Nineteen cases were radiosensitive embryonal carcinoma; 10 were embryonal adenocarcinoma, somewhat less sensitive; 3 were radioresistant chorioepithelioma, and 1, adult teratoma. The right testicle was involved 19 times, the left 18 times. Abdominal cryptorchidism with teratoma occurred 4 times. The Aschheim-Zondek reaction as carried out on these cases was positive in 85.7 per cent of the cases, but there is some question regarding the accuracy of this figure. Gynecomastia occurred in 2 cases.

Metastasis occurred both by lymphatic and hematogenous means. They are most frequent in the upper abdomen and in the external iliac on the same side as the primary tumor. If there are supraclavicular nodes other metastatic nodules may be present all along the thoracic duct. Inguinal nodes are not involved unless the tumor has perforated the tunica vaginalis or the capsule of the testicle. In 10 cases there was node involvement which extended from the pelvis to the left supraclavicular area. The mediastinal nodes were involved in 48 per cent; intracranial involvement was present in 16 per cent, and the lungs were involved in 48 per cent of the cases. Metastases to bones, genitourinary, and gastrointestinal tract, were less common. In nearly all the cases, there was bilateral involvement in the abdomen either of lymphatic glands or intra-abdominal organs.—*G. W. Chamberlin.*

Finestone, Edward O. Urinary extravasation (periurethral phlegmon). *Surg., Gynec., & Obst.*, Aug., 1941, *73*, 218–227.

The author states that seven factors play parts in determining the characteristics of extravasation: (1) anatomical distribution of fascial planes; (2) nature and location of the urethral lesion; (3) hydrostatic pressure of the extravesic fluid; (4) vascular obstruction induced by pressure of perineal abscess or extravasated fluid; (5) occurrence of vascular thrombosis or thrombophlebitis; (6) elasticity, tonicity, and contractility of the tissues and muscles; (7) nature of the invading organism.

In this article, there is a discussion of the anatomy of the perineum, followed by a series of experiments upon cadavers. Specimens were injected with radiopaque and colored solutions through a needle in the perineal triangle. Measurements were made of the amount injected and the pressure applied at intervals as control films were exposed.

These experiments failed to reveal any case wherein the tunica vaginalis testes was involved, so that operations on the deeper structures of the scrotum are considered unnecessary.

The author indicates the importance of diversion of the urinary stream in all cases of periurethral obstruction whether or not they have clinical evidence of obstruction.—*G. W. Chamberlin.*

Graves, R. C., and Guiss, L. W. Tumors of the urethra. *J. Urol.*, Nov., 1941, *46*, 935–947.

Primary urethral tumors are rare. The authors treat benign papillomata with radium implantation following biopsy and coagulation. In male patients they administer 200 mc-hr with a small brass or silver capsule introduc-

into the urethra. Carcinoma of the male urethra is very rare. The authors encountered 1 case in 19,000 admissions to a hospital for the treatment of neoplasms. The best treatment is amputation of the penis and radical dissection of the glands of the groin.

The commonest benign tumor of the female urethra is the caruncle. They tend to recur if incompletely removed. Electrodesiccation is the ideal method of treatment. Extensive scars must be avoided or strictures will result. Ten cases of carcinoma of the female urethra were encountered in the same series of 19,000 admissions in which 1 carcinoma of the male urethra was seen. The symptoms consist of bleeding, pain on urination, or urethral obstruction. Irradiation is gradually replacing radical surgery in the treatment of carcinoma of the female urethra.

The authors favor irradiation in the early and moderately advanced cases of epidermoid carcinoma. In advanced cases and especially in adenocarcinoma, radical surgical extirpation may be necessary. The authors use radium needles placed interstitially around and parallel to the lumen of the urethra, 0.5 cm. from its mucosa. Four needles are placed above, below and to each side of the urethra and a fifth needle in the midline just beneath the symphysis. Additional needles are introduced laterally and inferiorly for lymphatic blockage. The lymphatics drain to the inguinal glands.

One case report of epidermoid carcinoma in the male and one of benign papilloma in the male are presented together with case reports of 8 females with carcinoma of the urethra. In the presence of palpable inguinal glands the authors advise radical bilateral surgical dissection. They do not advise prophylactic dissection of the glands in the absence of palpable enlargement.—*R. M. Harvey.*

NERVOUS SYSTEM

HAMBY, WALLACE B. Misplaced spinal lipiodol: an analysis of 104 lipiodol spinograms. *Radiology*, Sept., 1941, *37*, 343–346.

A striking case of displacement of lipiodol led the author to make an analysis of 104 spinograms from the hospitals of Buffalo. He found displacement of the lipiodol into the subdural or epidural space in 8 of them, or 7.7 per cent. The oil had been introduced by cisternal puncture in 13 of these cases and by lumbar puncture in 91. It was misplaced in 3 of the cisternal cases, or 23 per cent, and in 5 of the lumbar cases, or 5.4 per cent.

If lipiodol is displaced into the epidural space it appears in the roentgenogram as a relatively fixed, irregular, opaque mass which a few days later tends to be widely diffused through the canal, either in the form of minute droplets or in that of a mass extending outward along the nerve roots. Subdural lipiodol flows rather freely but tends to outline defects that are not constant in serial studies. It remains more or less in a mass instead of becoming widely diffused.

The factor that was constant in these cases of displaced lipiodol was that spinal fluid pressure had been reduced previously either by lumbar puncture or, more commonly, by air spinography. Therefore it is advisable if lipiodol is to be injected after air spinography to wait at least ten days before injecting the oil.—*Audrey G. Morgan.*

SUBJECT INDEX TO VOLUME 49

(abs) = abstract (E.) = editorial

ABDOMEN, lower, diaphragmatic movement after operations on (abs), 275
ABSCESS, intraperitoneal localized, roentgen aid in diagnosis (abs), 276
ACIDOSIS, postoperative, occurrence of, in hyperparathyroidism (abs), 134
ACTINIC value of afterglow of fluorescing screen, quantitative estimation of (abs), 571
ADENOCARCINOMA, papillary, of kidney (abs), 835
ADRENAL GLANDS, metastasis to, from primary carcinoma of breast (abs), 136
tumors of, use of air insufflation in diagnosis (abs), 835
AIR INSUFFLATION, use of, in diagnosis of tumors of adrenal (abs), 835
ALIMENTARY TRACT, distant metastasis in cancer of (abs), 136
AMERICAN BOARD OF RADIOLOGY, announcement of dates of examination, 419
notice of examination to be held in 1943, 124
AMERICAN COLLEGE OF PHYSICIANS, notice of cancellation of 1943 annual session, 123
AMERICAN RADIUM SOCIETY, announcement of cancellation of 1943 meeting, 419
ANEURYSM of intercostal artery (abs), 274
ANGIOCARDIOGRAPHY in congenital heart disease, intracardiac shunts, 766
inexpensive cassette changer for, 829
ANKLE JOINT, osteochondritis of, use of tomography as diagnostic aid (abs), 426
ANKYLOSTOMIASIS, duodenal ulcer syndrome caused by, 39
AORTA, right-sided (abs), 274
APOPHYSEAL intervertebral joints, development, clinical manifestations, and treatment of rheumatoid arthritis of, 49
APPARATUS for radiography in immediate connection with roentgenoscopy (abs), 567
ARTERIOGRAPHY, cerebral, with diodrast, 50 per cent (abs), 706
ARTERY, intercostal, aneurysm of (abs), 274
ARTHRITIS, rheumatoid, of apophyseal intervertebral joints, development, clinical manifestations, and treatment of, 49
septic, of hip, obturator sign in early roentgen diagnosis of (E), 117
ASTHMA, chronic, therapeutic value of roentgen treatment in, 227
ATELECTASIS, recurrent postoperative (abs), 708
"reversible" and "irreversible" massive pulmonary, roentgen study (abs), 709
"BACK-SCATTER PHANTOM," portable, for roentgen-ray measurements (abs), 144
BICIPITAL GROOVE, roentgen studies of shoulder joint with special reference to (abs), 288
BILE DUCT, common, peristalsis of (abs), 132
terminal common, and duodenal papilla, roentgenological consideration (abs), 132
BIOPSY, limitations of, in roentgen therapy (abs), 566
material, human, from irradiated carcinomata, quantitative examination of (abs), 568
BLADDER, urinary, cancer of (abs), 282
urinary, distant metastases from carcinoma of (abs), 282
urinary, neoplasm complicating diverticulum of (abs), 283
urinary, osteoma of (abs), 283
urinary, roentgen demonstration of prevesical spaces (abs), 283
urinary, use of intravesical low voltage contact roentgen irradiation in cancer of (abs), 429
"BLAST CHEST," roentgen aspect of pulmonary changes following exposure to high pressure waves (abs), 712
BLEEDING associated with extramucosal tumors of stomach, 442
in hiatus hernia, 433
BONE and joint tuberculosis, statistical and roentgen analysis of 200 cases of (abs), 425
benign giant cell tumor of, late results obtained by radiation therapy (abs), 431
changes, pagetoid, in hyperparathyroidism (abs) 134
marrow, radiosensitiveness of (abs), 568
metastases from carcinoma of prostate, relationship of serum acid phosphatase determination to presence of (abs), 284
post-traumatic necrosis of, 593
primary malignant tumors of, roentgenologic considerations in diagnosis and treatment of (abs), 285
BONES, growing long, of albino rats, effect of roentgen rays upon, 321
short, of extremities, variability in onset of ossification in, 795
BOOK REVIEWS
An X-ray Atlas of Silicosis. By Arthur J. Am[illegible], 125
Malignant Disease and Its Treatment by Radium. By Stanford Cade, 125
The 1941 Year Book of Radiology. Edited by Charles A. Waters, Whitmer B. Fi[illegible], and Ira I. Kaplan, 126
Epilepsy and Cerebral Localization. By Wilder Penfield, 126
Clinical Roentgenology of Pregnancy. By William Snow, 265
Roentgen Treatment of Infections. By James F. Kelly, 265

Physical Medicine. By Frank H. Krusen, 266
The Treatment of Burns. By Henry N. Harkins, 266
The Doctors Mayo. By H. B. Clapesattle, 549
Roentgen Technique. By Clyde McNeill, 550
Nutrition and Chemical Growth in Childhood. Volume I. Evaluation. By Icie G. Macy, 550
Diseases of the Nails. By V. Pardo-Castello, 551
Surgical Physiology. By Joseph Nash, 551
Directory of Medical Specialists Certified by American Boards, 1942, 552
Intestinal Obstruction. By Owen H. Wangensteen, 700
Roentgen Interpretation. By George W. Holmes and Howard E. Ruggles, 701
Die Deutung des Röntgenschichtbildes der Longenspitzen bei Lungentuberkulose. By Wilhelm Kremer and Leonore Retzlaff, 701
X-Ray Therapy of Chronic Arthritis (Including the X-ray Diagnosis of the Disease). By Karl Goldhamer, 702
BRACHYESOPHAGUS with dystopic cardia (abs), 272
BRAIN TUMORS, experiences with roentgen irradiation following operation on, 480
irradiation of, at Bellevue Hospital 1924–1929 (abs), 430
roentgen therapy of (abs), 431
BREAST cancer, study of results following radical removal and postoperative roentgen therapy (abs), 431
extraordinary calcification in, 600
male, carcinoma of (abs), 713
primary carcinoma of, metastasis of (abs), 136
BRONCHI, stenosis of, and unexpandable lungs (abs), 709
BRONCHOMONILIASIS (abs), 711
BRONCHOPNEUMONIA associated with recent virus pneumonitis, roentgenographic characterization, 30
BRONCHOSCOPIC CLINIC (abs), 715
BULLETIN OF AMERICAN COLLEGE OF RADIOLOGY, 121
BURSITIS, calcified subacromial, roentgen irradiation of (abs), 558

CALCAREOUS DEPOSITS about shoulder, roentgen irradiation of (abs), 558
CALCIFICATION, extraordinary, in breast, 600
miliary, of lung, 777
of renal tumors, 580
CALCIFIED pulmonary lesions (E), 823
CALCINOSIS UNIVERSALIS (abs), 138
CALCULATOR, simple, for roentgenographic mensuration (abs), 574
CALDWELL LECTURE, 1942, 289
CANCER, cervical, post-irradiation stricture of rectum and sigmoid following treatment for
epithelial, classification of, based upon site of origin, 99
gynecological, present status of treatment of (abs), 141
instrument for inserting multiple capsules of radium within uterus in treatment of, 504
intrathoracic, million volt roentgen therapy for, 299
of bladder (abs), 282
of bladder, use of intravesical low voltage contact roentgen irradiation in (abs), 429
of breast, study of results following radical removal and postoperative roentgen therapy (abs), 431
of cervix, effect on rate of cure of increased roentgen radiation to parametria, 519
of cervix, elimination of irradiation injuries in treatment of, 494
of cervix, irradiation in (abs), 559
of esophagus, roentgen treatment of, 606
of head and face, protracted roentgen treatment of (abs), 140
of rectum and rectosigmoid treated with radium (abs), 561
of rectum, urological complications of (abs), 284
of stomach, factors influencing curability of (abs), 131
of upper respiratory and alimentary tracts, distant metastasis in (abs), 136
of uterine cervix, irradiation of, combining radium and supervoltage roentgen rays (abs), 560
of uterine cervix, isodose charts for fields of special usefulness in treatment of, 819
of uterus, results of present method of radium therapy as influenced by stage and grade of the lesion, 487
pharyngeal and laryngopharyngeal, surgery and radiation therapy in treatment (abs), 139
prostatic (abs), 836
research, newer aspects of, 289
rôle of gynecologist in field of, 1
significance of sedimentation reaction as regards prognosis of irradiation of patients with (abs), 567
Teaching Day, 419, 828
CAPILLARY permeability in skin of rabbit, effect of roentgen irradiation on, 250
CAPITATE, retrolunar dislocation of, with fracture or subluxation of navicular bone (abs), 288
CARCINOMA, advanced, of prostate gland, effects of castration on (abs), 836
epithelioma (abs), 135
gastric, classification of (abs), 139
irradiated, quantitative examination of human biopsy material taken from (abs), 568
metastatic, of epididymis (abs), 283
nasopharyngeal (abs), 706
of cervix, radium distribution factor in therapy of (abs), 560

depth, calculation, wherein absorption in unit volume in depth is index of effective radiation (abs), 572
depth, in fields of irregular shape (abs), 573
depth, survey of data on (abs), 573
DOSIMETERS, evolution of, in roentgen-ray therapy (abs), 572
DUCTUS ARTERIOSUS, patent, diagnosis of, 366
DUODENAL papilla and terminal common bile duct, roentgenological considerations (abs), 132
DUODENUM, congenital obstruction of (abs), 832
diverticula of (abs), 832
roentgen consideration of normal mucosa of (abs), 832
ulcer syndrome of, caused by ankylostomiasis, 39
DUST HAZARD in tremolite talc mining, 11
DYKE, CORNELIUS G., announcement of death of, 695
DYSCHEZIA, rectal (abs), 717

EAR, external, roentgenography of, 420
ECTOPIA, bilateral renal (abs), 281
EDEMA, pulmonary, roentgenological manifestations of (abs), 271
EDITORIALS
The obturator sign in the early roentgen diagnosis of septic arthritis of the hip, 117
Roentgenologic examination and, not or, gastroscopy, 259
Roentgenography as a diagnostic aid in pulmonary fat embolism, 410
Harry Myrrel Stewart, 1876–1942, 413
John Watson Cathcart, 1877–1942, 415
Megavoltage roentgen therapy, 540
Joseph Francis Elward, 1890–1943, 544
Pyelograms in essential or hormonal hypertension, 692
Edward George Meter, 1876–1943, 694
Calcified pulmonary lesions, 823
EFFECT, indirect, of roentgen rays in single and parabiotic mice, 662
of emotions upon esophageal function (abs), 715
of hard roentgen rays on intestines of normal dogs fed on inorganic compounds (abs), 142
of high and low body temperatures upon growth of irradiated mouse sarcoma 180 (abs), 568
of roentgen irradiation on capillary permeability and inflammation in skin of rabbit, 250
of roentgen irradiation on epiphyseal growth, 104
of roentgen irradiation upon lymphatic flow in rats (abs), 567
of roentgen rays upon growing long bones of albino rats, 321
of roentgen therapy for closure of epiphyses (abs), 558
of shock-proof cables and condensers on two-valve half-wave rectification (abs), 571
EFFUSION, pleural, roentgenographic study of (abs), 274
EISENMENGER COMPLEX, diagnosis of, 366
ELECTROCARDIOGRAPHY and roentgen cinematography, study of cardiac movements simultaneously recorded by (abs), 570
ELWARD, JOSEPH FRANCIS, 1890–1943, obituary, 544
portrait, 544
EMBOLISM, pulmonary fat, roentgenography as diagnostic aid in (E), 410
ENDOCHONDRAL growth centers, histopathological changes involving, in albino rats after roentgen irradiation, 321
ENERGY absorption (abs), 144
ENGINEERING RESEARCH, recent contributions of, to radiology (abs), 570
EPIDERMITIS, severe irradiation, ointment for relief of discomfort due to (abs), 566
EPIDERMOIDS, intraspinal (abs), 137
EPIDIDYMIS, metastatic carcinoma of (abs), 283
EPIDUROGRAPHY, new method of demonstrating protrusion of intervertebral disc (abs), 426
EPIPHYSEAL growth, effect of roentgen irradiation on, 104
EPIPHYSES, effect of roentgen therapy for closure of (abs), 558
of extremities, variability in onset of ossification in, 795
EPITHELIAL cancers, classification of, based upon site of origin, 99
ERYTHEMA NODOSUM, mediastinal and pulmonary changes in (abs), 271
ESOPHAGUS, brachyesophagus with dystopic cardia (abs), 272
cancer, million volt roentgen therapy for, 299
cancer, roentgen treatment of, 606
congenital short, 185
influence of emotions upon function of (abs), 715
report of case of mega-esophagus, with subdiaphragmatic herniation of (abs), 272
EUSTACHIAN TUBE, radiological visualization of (abs), 706
EVOLUTION of x-ray tube (abs), 143
EWING'S TUMOR, gradation of (abs), 285
EXTRAMUCOSAL tumors of stomach, bleeding associated with, 442
EXTRAVASATION, urinary (abs), 837
EXTREMITIES, variability in onset of ossification in epiphyses and short bones of, 795
EXTREMITY, upper, carcinoma of (abs), 135
EYES, cataracts, roentgen measurement of visual acuity in (abs), 269

FACE, cancer, protracted roentgen treatment of (abs), 140
cavernous hemangioma of, in infant treated with radium, 816
FEMOROPATELLAR JOINT, roentgenology of (abs), 425
FEMUR, aseptic necrosis of head of, following trau-

of cervix, roentgen irradiation of pelvis in (abs), 558
of head of pancreas, new signs in roentgen diagnosis, 197
of large intestine (abs), 132
of lower intestinal tract (abs), 131
of male breast (abs), 713
of pelvic colon, combined irradiation and surgery in treatment of (abs), 561
of prostate, relationship of serum acid phosphatase determination to presence of bone metastases from (abs), 284
of prostate with irradiation of testicles, treatment of (abs), 562
of upper extremity (abs), 135
of urinary bladder, distant metastases from (abs), 282
oral (abs), 705
papillary, of renal pelvis, diagnosis and treatment (abs), 835
primary, of breast, metastasis of (abs), 136
primary, of jejunum (abs), 275
value of gastroscopy in diagnosis of (abs), 716
CARDIA, dystopic, brachyesophagus with (abs), 272
CARDIOSPASM (abs), 272
CARPAL boss, commonly overlooked deformity of carpus (abs), 287
scaphoid, conservative and operative treatment of fractures of (abs), 288
CASSETTE changer, inexpensive, for angiocardiography, 829
CASTRATION, effects of, on advanced carcinoma of prostate gland (abs), 836
CATHCART, JOHN WATSON, 1877–1942, obituary, 415
portrait, 415
CELL division, multipolar, induction of, with roentgen rays, possible significance (abs), 569
CEREBRAL arteriography with diodrast, 50 per cent (abs), 706
CHAOUL THERAPY (abs), 429
further experiences with (abs), 430
CHEST. See THORAX
CHILDREN, diagnosis of congenital heart lesions in, 366
excretory urography for (abs), 279
limitations of irradiation of solid renal tumors in (abs), 562
study of gastrointestinal tract of, and its relation to adult (abs), 718
study of "widened" mediastinum in, and pitfalls in diagnosis, 159
CHOLANGIOGRAPHY, fractional method (abs), 833
CHOLECYSTOGRAPHY, aid in, 699
CHONDRYODYSTROPHIA calcificans congenita, 77
Clostridium welchii infection, experimental, in dogs, roentgen radiation in (abs), 564
COCCIDIOIDOMYCOSIS, acute, roentgen findings in a group "epidemic" (abs), 707
COLON, pelvic, combined irradiation and surgery in treatment of carcinoma of (abs), 561
COMPRESSION of heart (abs), 273
CONDENSERS and shock-proof cables, effect of, on two-valve half-wave rectification (abs), 571
CONGENITAL duodenal obstruction (abs), 832
heart disease, angiocardiography in, 766
heart lesions in children, diagnosis of, 366
tracheoesophageal fistula (abs), 713
valvular lesions, diagnosis, of, 366
CONGRESS OF RADIOLOGY, First Inter-American, 698
CONTACT roentgen therapy tubes, simple way to hold filter in place on, 128
CONTRAST media, roentgen visualization of stomach without use of (abs), 275
visualization of heart and great vessels (abs), 273
COR PULMONALE, chronic, relation to pulmonary tuberculosis (abs), 710
COUTARD'S METHOD of roentgen therapy (abs), 140
CYCLIC CHANGES in mammary gland of Rhesus monkey (abs), 143
CYST, hydatid, of liver (abs), 132
CYSTIC disease of kidney, atypical pyelograms in (abs), 278
lungs of rare origin (abs), 271
CYSTS, myxomatous cutaneous, roentgen treatment of (abs), 566

DEFORMITY of carpus, commonly overlooked (abs), 287
DERMATOLOGY, irradiation in (abs), 566
DERMOIDS (abs), 137
DEXTROCARDIA, diagnosis of, 366
DIAPHRAGM, hernia, roentgenologic considerations in diagnosis and treatment of, 185
movement of, after lower abdominal operations (abs), 275
DIAPHRAGMATIC hernia of stomach (abs), 276
hernia, parasternal, with report of case on right side (abs), 717
DILATATIONS of spinal cord veins, roentgen diagnosis of, 476
DIODRAST, 50 per cent, cerebral arteriography with (abs), 706
DISLOCATION, retrolunar, of capitate with fracture or subluxation of navicular bone (abs), 288
traumatic, of hip, aseptic necrosis of femoral head following (abs), 428
DIVERTICULA of duodenum (abs), 832
DIVERTICULUM of bladder, neoplasm complicating (abs), 283
DOGS, normal, effect of hard roentgen rays on intestines of, fed on inorganic iron compounds (abs), 142
roentgen radiation in experimental Clostridium welchii infection in (abs), 564
DOSAGE distribution in radiation therapy, homogeneity of (abs), 573
integration of radiation, and absorption of energy in tissue for roentgen and gamma radiation (abs), 573
DOSE contours, geometrical methods of projecting (abs), 432

small, clinical significance of roentgen findings of (abs), 833
small, roentgen changes in, in presence of hookworm, 719
Intestines of normal dogs fed on inorganic iron compounds, effect of hard roentgen rays on (abs), 142
Intraperitoneal abscess, localized, roentgen aid in diagnosis (abs), 276
Intrathoracic cancer, million volt roentgen therapy for, 299
manifestations of lymphomatoid diseases (abs), 273
neurogenic tumors (abs), 714
Irido-cyclitis, chronic, uveo-parotitis and tuberculosis, roentgen aspects of investigation into relationship of (abs), 270
Iron compounds, inorganic, effect of hard roentgen rays on intestines of normal dogs fed on (abs), 142
Irradiation and surgery, combined, in treatment of carcinoma of pelvic colon (abs), 561
control of testicular tumor metastases (abs), 562
epidermitis, severe, ointment for relief of discomfort due to (abs), 566
in dermatology (abs), 566
injuries, elimination of, in treatment of cancer of cervix, 494
limitations of, of solid renal tumors in children (abs), 562
of cancer of uterine cervix, combining radium and supervoltage roentgen rays (abs), 560
of cancer patients, significance of sedimentation reaction as regards prognosis of (abs), 567
of liquids (abs), 143
of testicles, treatment of carcinoma of prostate with (abs), 562
sickness, prevention of, 83
sickness, studies in (abs), 138
stricture of rectum and sigmoid following treatment for cervical cancer, 307
Isodose charts for fields of special usefulness in treatment of cancer of uterine cervix, 819

Janeway Lecture, 1942, 1
medal, for 1942, presentation of, 10
Jejunum, primary carcinoma of (abs), 275
Johnson stereoroentgenometer, analysis of roentgen pelvimetry by, in 379 cases, 742
Joints, apophyseal intervertebral, rheumatoid arthritis of, 49

Kidney, atypical pyelograms in cystic disease of (abs), 278
bilateral ectopia of (abs), 281
calcification of tumors of, 580
exploration of certain tumors of (abs), 281
increasing density of shadow of, during excretion urography (abs), 278
papillary adenocarcinoma of (abs), 835
papillary carcinoma of pelvis of, diagnosis and treatment (abs), 835
primary intrarenal lipoma of surgical significance (abs), 280
return of function of, after long apparent absence (abs), 562
roentgenology of tuberculosis of (abs), 279
solid tumors of, in children, limitations of irradiation of (abs), 562
spontaneous rupture of pelvis of (abs), 280
subcapsular rupture of (abs), 280
tuberculoma of (abs), 281
tubules, reaction of, in tissue culture to roentgen rays (abs), 569
Kirklin, B. R., appointed x-ray consultant in Office of Surgeon General of Army, 828
Knee joint, good projection for (abs), 425

Laryngopharynx, cancer, surgery and radiation therapy in treatment (abs), 139
Leiomyosarcoma of prostate gland (abs), 836
of stomach, 393
Leukemia, chronic macrolymphocytic and mesolymphocytic lymphatic, roentgen therapy for (abs), 565
retention in blood, excretion and therapeutic effect of radio-phosphorus on patients with (abs), 142
Light reversal process, duplications of roentgenograms by, 554
Lipiodol, misplaced spinal (abs), 838
Lipoma, primary intrarenal, of surgical significance (abs), 280
Liquids, irradiation of (abs), 143
Lithiasis, pancreatic (abs), 276
Liver, hydatid cyst of (abs), 132
Lobectomy, pulmonary, postoperative complications of (abs), 713
Localization, roentgenologic, of placenta without contrast media, 750
Lungs, calcified lesions of (E), 823
cancer, million volt roentgen therapy for, 299
changes in, in erythema nodosum (abs), 271
cystic, of rare origin (abs), 271
miliary calcification of, 777
postoperative complications of pulmonary lobectomy (abs), 713
pyogenic osteomyelitis of thoracic spine presenting as primary disease of, 219
roentgen aspect of changes in, following exposure to high pressure waves (abs), 712
roentgenography as diagnostic aid in fat embolism of (E), 410
roentgenological manifestations of edema of (abs), 271
traumatic changes in, through blunt violence to thorax, roentgen investigation (abs), 271
unexpandable (abs), 709
Lymphadenitis, tuberculous cervical, roentgen therapy in (abs), 563

matic dislocation of hip (abs), 428
device to aid in positioning for lateral roentgenograms of neck of, 264
Fetal and pelvic diameters, accuracy of roentgen estimates of (abs), 834
Fibrosarcoma, periosteal (abs), 134
Filter, simple way to hold in place on contact therapy tubes, 128
Fistula, congenital tracheoesophageal (abs), 713
gastrocolic (abs), 718
Fluoroscopic room, stray radiation in, 123
Focal spot size determination, accuracy of (abs), 572
Foreign body, new method of determining position of, from single-film stereoroentgenograms, 682
Fracture of navicular bone, retrolunar dislocation of capitate with (abs), 288
Fractures, limitations of roentgen diagnosis of (abs), 133
of carpal scaphoid, conservative and operative treatment of (abs), 288
of vertebrae following metrazol therapy (abs), 428

Gas gangrene, experimental infection in dogs, roentgen radiation in (abs), 564
twelve year review of roentgen therapy of (abs), 564
Gastritis, chronic, surgical problem of (abs), 130
Gastrocolic fistula (abs), 718
Gastrointestinal tract of children and its relation to the adult, study of (abs), 718
Gastroscopist and roentgenologist, value of cooperation between (abs), 716
Gastroscopy and roentgen examination (E), 259
practical evaluation of (abs), 716
unusual sequel to (abs), 717
Geometrical methods of projecting dose contours (abs), 432
Georgia Radiological Society, 264
Ghon's tubercle, re-evaluation of a concept, 463
Guinea pig, roentgen treatment of experimental pneumonia in (abs), 569
Gynecological cancer, present status of treatment of (abs), 141
Gynecologist, rôle of, in field of cancer, 1

Head, cancer, protracted roentgen treatment of (abs), 140
malformation of, in mongoloid deficiency (abs), 705
Healy, William P., Janeway Lecturer, 1942, portrait opposite page 1
Heart, and great vessels, contrast visualization (abs), 273
compression of (abs), 273
congenital lesions of, in children, diagnosis, 366
disease, congenital, angiocardiography in, 766
study of movement of, simultaneously recorded by roentgen-cinematography and electrocardiography (abs), 570
Hemangioma, cavernous, of face in infant treated with radium, 816
of vertebrae (abs), 427
Hemangiomata, roentgen therapy of (abs), 564
Hernia, diaphragmatic, of stomach (abs), 276
diaphragmatic, roentgenologic considerations in diagnosis and treatment of, 185
hiatus, bleeding in, 433
parasternal diaphragmatic, with report of case on right side (abs), 717
Hiatus hernia, bleeding in, 433
Hip, aseptic necrosis of femoral head following traumatic dislocation of (abs), 428
obturator sign in early roentgen diagnosis of septic arthritis of (E), 117
Hookworm, roentgen changes in small intestine in presence of, 719
Hunner's ulcer, treatment of, with deep roentgen therapy (abs), 563
Hydatid cyst of liver (abs), 132
Hydrocephalus, intrauterine, roentgen diagnosis of (abs), 834
Hyperparathyroidism, occurrence of postoperative acidosis and pagetoid bone changes in (abs), 134
Hypertension, essential or hormonal, pyelograms in (E), 692

Image reinforcement, latent in fluorescing screen, simple method of detecting experimentally presence of phenomenon of (abs), 571
Infant, cavernous hemangioma of face in, treated with radium, 816
Infantile scurvy, critical analysis of roentgen signs of, 575
Infants, mediastinal pleurisy in, 145
Inflammation in skin of rabbit, effect of roentgen irradiation on, 250
Injuries, irradiation, elimination of, in treatment of cancer of cervix, 494
Interauricular septum, defect of, diagnosis, 366
Interventricular septum, defect of, diagnosis, 366
Intervertebral disc, diagnosis of posterior protrusion of, 199
disc, epidurography a new method of demonstrating protrusion of (abs), 426
disc, protruded, intraspinal thorotrast use in diagnosis of, 214
disc, ruptured, surgical aspects of (abs), 426
disc, significance of degenerative lesions of, 199
joints, apophyseal, developmental, clinical manifestations and treatment of rheumatoid arthritis of, 49
Intestinal tract, lower, carcinoma of (abs), 131
Intestine, large, carcinoma of (abs), 132
small, changes in, in irradiation sickness (abs), 138

Lymphangioma, radiation treatment of, 799
Lymphatic flow in rats, effect of roentgen irradiation upon (abs), 567
Lymphoblastoma, radiotherapy of (abs), 565
Lymphogranuloma inguinale producing rectal stricture (abs), 277
Lymphomatoid diseases, intrathoracic manifestations of (abs), 273
Lymphosarcoma of prostate gland (abs), 836
secondary, of stomach, 450

Malformation of head in mongoloid deficiency (abs), 705
Mammary gland of Rhesus monkey, cyclic changes in (abs), 143
Measurement, roentgen, of visual acuity in cataractous eyes (abs), 269
simple calculator for roentgenographic (abs), 574
Measurements, roentgen-ray, portable "back-scatter phantom" for (abs), 144
Mediastinal changes in erythema nodosum (abs), 271
pleurisy in infants, 145
Mediastinum, study of "widened" in children, pitfalls in diagnosis, 159
Mega-esophagus (abs), 272
Megarectum, rectal dyschezia a misnomer for (abs), 717
Megavoltage roentgen therapy (E), 540
Melorheostosis (abs), 286
report of bilateral case, 398
Mesothorium, toxicity of, 240
Metabolic disturbances, roentgen changes in cranial vault accompanying diseases resulting from (abs), 269
Metastases, bone, from carcinoma of prostate, relationship of serum acid phosphatase determination to presence of (abs), 284
distant, from carcinoma of urinary bladder (abs), 282
distant, in cancer of upper respiratory and alimentary tracts (abs), 136
of primary carcinoma of breast (abs), 136
soft tissue, from multiple myeloma (abs), 137
subepidermal lymphatic, confused with operative sequelae (abs), 135
testicular tumor, irradiation control of (abs), 562
Metastatic carcinoma of epididymis (abs), 283
Meter, Edward George, 1876–1943, obituary, 694
portrait, 694
Metrazol therapy, fractures of vertebrae following (abs), 428
Mice, single and parabiotic, indirect effect of roentgen rays in, 662
Miliary calcification of lung, 777
Milliammeters as ground potential in roentgen tube circuits (abs), 574
Minnesota Radiological Society, 698
Mongoloid deficiency, malformation of head in (abs), 705
Mouse sarcoma 180, effect of high and low body temperatures upon growth of irradiated (abs), 568
Mouth, carcinoma of (abs), 705
Mucosa, normal, of duodenum, roentgenologic consideration of (abs), 832
Mucous membranes, artificial decrease of radiosensitivity of, in roentgen therapy, 811
Multipolar cell division, induction of, with roentgen rays, possible significance (abs), 569
Myelography, contrast, interpretation of, in diagnosis of posterior protrusion of intervertebral disc, 199
intraspinal thorotrast used in, 214
thorotrast, demonstration of ruptured intervertebral disc by (abs), 426
Myeloma, endothelial (abs), 285
multiple, with special reference to soft tissue metastasis (abs), 137
Myxomatous cutaneous cysts, roentgen treatment of (abs), 566

Nasal sinusitis (abs), 707
Nasopharynx, carcinoma of (abs), 706
National Bureau of Standards, new x-ray laboratory of (abs), 570
Navicular bone of foot, bipartite (abs), 426
retrolunar dislocation of capitate with fracture or subluxation of (abs), 288
Necator americanus, infestation with, cause of deficiency pattern in small intestine, 719
Necrosis, aseptic, of femoral head following traumatic dislocation of hip (abs), 428 post-traumatic, of bone, 593
Nephrectomy in certain renal tumors (abs), 281
Neurinoma of thorax, roentgen diagnosis of (abs), 715
Neurogenic tumors, intrathoracic (abs), 714
Neutron emission from generator operating at 200 kv. (abs), 144
Nomogram for determination of lead protection against high voltage roentgen rays (abs), 432

Obstetrical pelvicephalometry, roentgenographic, in erect posture, 731
Obturator sign in early roentgen diagnosis of septic arthritis of hip (E), 117
Oil aspiration pneumonia, 177
Ointment for relief of discomfort due to severe irradiation epidermitis (abs), 566
Os naviculare pedis, bipartite (abs), 426
Ossification in epiphyses and short bones of extremities, variability in onset of, 795
Osteochondritis dissecans of ankle joint, use of tomography as diagnostic aid (abs), 426

OSTEOGENESIS IMPERFECTA, its incidence and manifestations in seven families (abs), 133
OSTEOGENIC sarcoma (abs), 135
OSTEOMA of bladder (abs), 283
OSTEOMYELITIS, pyogenic, of thoracic spine presenting as primary pulmonary disease, 219
OSTEOPETROSIS, prenatal diagnosis of, 455
OSTEOPOIKILOSIS, 603
OTORRHEA, chronic, radium therapy as aid in control of, 234
OVARIES, metastasis to, from primary carcinoma of breast (abs), 136

PALATE, malignant tumors, end-results of treatment of (abs), 140
PANCREAS, acute necrosis of (abs), 832
carcinoma of head of, new signs in roentgen diagnosis, 197
lithiasis of (abs), 276
tumors of, roentgen study (abs), 276
PAPILLOMA, malignant, complicating diverticulum of bladder (abs), 283
PELVIC and fetal diameters, accuracy of roentgen estimates of (abs), 834
PELVICEPHALOMETRY, roentgenographic obstetrical, in erect posture, 731
PELVIMETRY, roentgen, analysis of, by Johnson stereoroentgenometer in 379 cases, 742
PELVIS, roentgen irradiation of, in carcinoma of cervix uteri (abs), 558
PERICARDITIS, chronic constrictive, contributions of roentgenology to diagnosis of, 349
PERIOSTEAL fibrosarcoma (abs), 134
PERISTALSIS, common bile duct (abs), 132
PERITENDINITIS CALCAREA in shoulder joint, treatment of (abs), 558
PERITONEUM, intraperitoneal localized abscess, roentgen aid in diagnosis (abs), 276
PERSIMMON phytobezoar (abs), 130
PFAHLER, GEORGE E., science hall named in honor of, 263
PHARYNX, cancer, surgery and radiation therapy in treatment (abs), 139
roentgen examination of, 587
PHLEGMON, periurethral (abs), 837
PHOSPHATASE determination, serum acid, relationship of, to presence of bone metastases from carcinoma of prostate (abs), 284
PHOTOGRAPHY, miniature screen, comparison of, with direct roentgenography (abs), 567
PHOTOROENTGEN unit, stereoscopic, ten thousand chest examinations with, 469
PHYSICAL factors concerned in indirect roentgenography, research into (abs), 570; (abs), 571
investigations with 140 kvp (peak) radiation (abs), 572
PHYSICS, recent contributions of, to radiology (abs), 570
PHYTOBEZOAR, persimmon (abs), 130

PLACENTA, roentgenologic localization of, without contrast media, 750
PLEURAL effusion, roentgenographic study of (abs), 274
PLEURISY, mediastinal, in infants, 145
PNEUMONIA, experimental, in guinea pig, roentgen treatment of (abs), 569
lipoid, report of case simulating bronchial carcinoma (abs), 711
oil aspiration, 177
virus, 30
virus, roentgen therapy of, 635
PNEUMONITIS, virus, with bronchopneumonia, roentgenographic characterization of, 30
PNEUMOPERITONEUM, spontaneous, roentgen sign found in supine position (abs), 833
POLYCYTHEMIA, absorption and distribution of radio-phosphorus in blood of, its excretion by, and its therapeutic effect on, patients with (abs), 142
PREVESICAL spaces, roentgen demonstration of (abs), 283
PROSTATE GLAND, effects of castration on advanced carcinoma of (abs), 836
leiomyosarcoma of (abs), 836
lymphosarcoma of (abs), 836
relationship of serum acid phosphatase determination to presence of bone metastases from carcinoma of (abs), 284
treatment of carcinoma of, with irradiation of testicles (abs), 562
PROTECTION, features of, provided with United States Army Field roentgenoscopic equipment, 653
lead, nomogram for determination of, against high volatge roentgen rays (abs), 432
PROTECTIVE device, radium loading, new type of, 803
PROTRUSION, posterior, of intervertebral disc, diagnosis of, 199
PSEUDOFRACTURES in diseases affecting skeletal system (abs), 287
PYELOGRAMS, atypical, in cystic disease of kidney (abs), 278
in essential or hormonal hypertension (E), 692
retrograde, backflow of opaque medium in (abs), 278
excretion, increasing density of renal shadow during (abs), 278
excretory, for children (abs), 279
intravenous, in upright position (abs), 279
intravenous, value of, in study of metastasis of testicular tumors (abs), 562
layer formation in, 783
PYELONEPHRITIS, localized obliterating (abs), 282
PYELORENAL backflow (abs), 278
PYLORUS, new roentgen sign of obstruction of (abs), 275
PYOGENIC osteomyelitis of thoracic spine presenting as primary pulmonary disease, 219

RABBIT, effect of roentgen irradiation on capillary permeability and inflammation in skin of, 250
RADIATION damage to tissue and its repair (abs), 139
depth dose calculation wherein absorption in unit volume in depth is index of effective (abs), 572
dosage, integration of, and absorption of energy in tissue for roentgen and gamma radiation (abs), 573
hazards during roentgenoscopy, 639
140 kv. (peak) physical investigations with (abs). 572
sickness. See Irradiation sickness
stray, in fluoroscopic room, 123
surface, distribution of, from million-volt generator (abs), 573
teletherapy, homogeneity of dosage distribution in (abs), 573
therapy, late results in benign giant cell tumor of bone obtained by (abs), 431
treatment of lymphangioma, 799
RADIOACTIVE substances, short-lived, harmlessness of, 240
RADIOLOGICAL Research Laboratory of Columbia University, 263
RADIOLOGISTS, open letter to, 121
RADIOLOGY, recent contributions of physics and engineering research to (abs), 570
RADIO-PHOSPHORUS, absorption and distribution of, in blood of, its excretion by, and its therapeutic effect on, patients with polycythemia (abs), 142
clinical studies with aid of (abs), 142
retention in blood, excretion and therapeutic effect of, on patients with leukemia (abs), 142
RADIOSENSITIVENESS of bone marrow (abs), 568
RADIOSENSITIVITY of skin and mucous membranes in roentgen therapy, artificial decrease of, 811
RADIOTHERAPY of lymphoblastoma (abs), 565
RADIUM and supervoltage roentgen rays, technique of irradiation of cancer of uterine cervix combining (abs), 560
cavernous hemangioma of face in infant treated with, 816
distribution factor in therapy of carcinoma of cervix (abs), 560
instrument for inserting multiple capsules of, within uterus in treatment of corpus cancer, 504
loading protective device, new type of, 803
malignant disease of rectum and rectosigmoid treated with (abs), 561
therapy, mild, definition and method of application, 240
therapy, results of present method of, as influenced by stage and grade of cancer of uterus, 487
toxicity of, 240
RADON seed, accurate placement of, by suture method (abs), 141
treatment, 240
RATS, albino, effect of roentgen rays upon growing long bones of, 321
albino, experimental studies upon, on effect of roentgen irradiation on epiphyseal growth, 104
effect of roentgen irradiation upon lymphatic flow in (abs), 567
RECTOSIGMOID, cancer of, treatment with radium (abs), 561
RECTUM, cancer of, treatment with radium (abs), 561
dyschezia of (abs), 717
lympho-granuloma inguinale producing stricture of (abs), 277
post-irradiation stricture of, following treatment for cervical cancer, 307
roentgenologic features of tuberculosis of (abs), 277
urological complications of cancer of (abs), 284
RESPIRATORY TRACT, upper, distant metastasis in cancer of (abs), 136
RHESUS monkey, cyclic changes in mammary gland of (abs), 143
RHEUMATOID arthritis of apophyseal intervertebral joints, development, clinical manifestations and treatment of, 49
RHOADS, C. P., Caldwell lecturer, 1942, 289
portrait opposite page 289
ROENTGEN changes in cranial vault accompanying diseases resulting from metabolic disturbances (abs), 269
cinematography and electrocardiography, study of cardiac movements simultaneously recorded by (abs), 570
demonstration of prevesical spaces (abs), 283
diagnosis, early, of septic arthritis of hip, obturator sign in (E.), 117
diagnosis of fractures, limitations of (abs), 133
estimates of pelvic and fetal diameters, accuracy of (abs), 834
film, miniature, of chest (abs), 715
irradiation, effect of, on capillary permeability and inflammation in skin of rabbit, 250
irradiation, effect of, on epiphyseal growth, 104
irradiation, effect of, upon lymphatic flow in rats (abs), 567
irradiation, experiences with, following operation on brain tumors, 480
laboratory, new, of National Bureau of Standards (abs), 570
measurement of visual acuity in cataractous eyes (abs), 269
radiation, effect on rate of cure of cancer of cervix, of increased roentgen radiation to parametria, 51
radiation in experimental *Clostridium welchii* infection in dogs (abs), 564

-ray equipment and accessories, urge ... ubes, contact, simple way to hold filter conserving, 263
-ray findings compared with patch ... ace on, 128
tests (abs), 712 ... use of intravesical low voltage contact, in cancer of bladder (abs), 429
-ray generator, million-volt, distribution of surface radiation from (abs), 573
-ray measurements, portable "back-scatter phantom" for (abs), 144
-ray stereoptics, investigation into some practical aspects of, 682
-ray tube, evolution of (abs), 143
rays, clinical observations on use of 3 million volt, 536
rays, effect of, upon growing long bones of albino rats, 321
rays, hard, effect of, on intestines of normal dogs fed on inorganic iron compounds (abs), 142
rays, high voltage, nomogram for determination of lead protection against (abs), 432
rays, indirect effect of, in single and parabiotic mice, 662
rays, induction of multipolar cell division with, possible significance (abs), 569
rays, production and characteristics of 3,000 kilovolt, 531
rays, reaction of kidney tubules in tissue culture to (abs), 569
rays, supervoltage, and radium, technique of irradiation of cancer of uterine cervix combining (abs), 560
sign, new, of pyloric obstruction (abs), 275
signs of infantile scurvy, critical analysis, 575
therapy as aid in control of chronic otorrhea, 234
therapy, deep, treatment of Hunner's ulcer with (abs), 563
therapy, effect of, for closure of epiphyses (abs), 558
therapy, evolution of dosimeters in (abs), 572
therapy for chronic macrolymphocytic and mesolymphocytic lymphatic leukemia (abs) 565
therapy in tuberculous cervical lymphadenitis (abs), 563
therapy, limitations of biopsy in (abs), 566
therapy, low voltage contact (abs), 429; (abs), 430
therapy, megavoltage (E), 540
therapy, million volt, for intrathoracic cancer, 299
therapy of gas gangrene, twelve year review of (abs), 564
therapy of hemangiomata (abs), 564
therapy of myxomatous cutaneous cysts (abs), 566
therapy of virus pneumonia, 635
therapy, supervoltage, results obtained with, in treatment of gynecological cancer (abs), 141
therapy use of vitamin B_1 in, for prevention of irradiation sickness, 83
treatment in chronic asthma, therapeutic value in, 227
treatment of cancer of esophagus, 606
treatment of experimental pneumonia in guinea pig (abs), 569
treatment, protracted, of malignancies, particularly of head and face (abs), 140
tube circuits, milliammeters at ground potential in (abs), 574
ROENTGENOGRAMS, duplication of, by light reversal process, 554
lateral, of femoral neck, device to aid in positioning of, 264
ROENTGENOGRAPHIC mensuration, simple calculator for (abs), 574
study of relative incidence of gastric and duodenal ulcer (abs), 275
ROENTGENOGRAPHY as diagnostic aid in pulmonary fat embolism (E), 410
direct, comparison of miniature screen photography with (abs), 567
in immediate connection with roentgenoscopy, apparatus for (abs), 567
indirect, optimum combination of film and fluorescing screen for use in (abs), 570
indirect, research into physical factors concerned in (abs), 570; (abs), 571
mass, rôle of, in tuberculosis (abs), 270
of external ear, 420
ROENTGENOLOGIC considerations in diagnosis and treatment of primary malignant bone tumors (abs), 285
examination and, not or, gastroscopy (E), 259
ROENTGENOLOGIST and gastroscopist, value of cooperation between (abs), 716
ROENTGENOLOGY, contribution of, to diagnosis of chronic constrictive pericarditis, 349
of femoropatellar joint (abs), 425
of renal tuberculosis (abs), 279
ROENTGENOSCOPIC equipment, United States Army Field, protective features provided with, 653
ROENTGENOSCOPY, apparatus for roentgenography in immediate connection with (abs), 567
radiation hazards during, 639
ROGER'S DISEASE, diagnosis of, 366
RUPTURE, spontaneous, of renal pelvis (abs), 280
subcapsular, of kidney (abs), 280

SARCOMA 180, mouse, effect of high and low body temperatures upon growth of irradiated (abs), 568
osteogenic (abs), 138
SCLEROSIS, tuberous, three cases of, cystic lungs from (abs), 271

THORAX, blast injuries of, roentgen aspect of pulmonary changes following exposure to high pressure waves (abs), 712
intrathoracic cancer, million volt roentgen therapy for, 299
intrathoracic manifestations of the lymphomatoid diseases (abs), 273
miniature x-ray film of (abs), 715
roentgen diagnosis of neurinoma of (abs), 715
ten thousand examinations of, with stereoscopic photoroentgen unit, 469
traumatic lung changes through blunt violence to, roentgen investigation (abs), 271
THOROTRAST, intraspinal, 214
myelography, demonstration of ruptured intervertebral disc by (abs), 426
THYMUS, relation of mediastinal shadow to, 159
TISSUE culture, reaction of kidney tubules in, to roentgen rays (abs), 569
integration of radiation dosage and absorption of energy in, for roentgen and gamma radiation (abs), 573
radiation damage to, and its repair (abs), 139
soft, metastasis to, from multiple myeloma (abs), 137
TOMOGRAPHY, use of, as diagnostic aid in osteochondritis dissecans of ankle joint (abs), 426
TRACHEOESOPHAGEAL fistula, congenital (abs), 713
TRAUMA, lesions of lungs from blunt violence to thorax, roentgen investigation (abs), 271
necrosis of bone following, 593
TREMOLITE talc mining, dust hazard in, 11
TUBERCLE, Ghon's, 463
TUBERCULIN tests and roentgen-ray correlation (abs), 712
TUBERCULOMA of kidney (abs), 281
TUBERCULOSIS, bone and joint, statistical and roentgen analysis of 200 cases of (abs), 425
examination for, with stereoscopic photoroentgen unit, 469
irido-cyclitis, and uveo-parotitis, roentgen aspects of investigation into relationship of (abs), 270
of rectum, roentgen features of (abs), 277
primary, in adolescents and young adults (abs), 709
pulmonary, relation of chronic cor pulmonale to (abs), 710
renal, roentgenology of (abs), 279
rôle of mass roentgenography in (abs), 270
TUBERCULOUS cervical lymphadenitis, roentgen therapy in (abs), 563
TUMOR, benign giant cell, of bone, late results in, obtained by radiation therapy (abs), 431
Ewing's, irradiation of (abs), 285
Wilms', treatment of (abs), 561
TUMORS, brain, experiences with roentgen irradiation following operation on, 489
brain, irradiation of, at Bellevue Hospital 1924–1929 (abs), 430
certain renal, exploration of (abs), 281
extramucosal, of stomach, bleeding associated with, 442
hypernephroid (abs), 835
intrathoracic neurogenic (abs), 714
malignant, of palate, end-results of treatment of (abs), 140
of adrenal, use of air insufflation in diagnosis (abs), 835
of brain, roentgen therapy of (abs), 431
of spinal cord, roentgen therapy of (abs), 431
of urethra (abs), 837
pancreatic, roentgen study (abs), 276
primary malignant bone, roentgenologic considerations in diagnosis and treatment of (abs), 285
renal, calcification of, 580
solid renal, in children, limitations of irradiation of (abs), 562
TYMPANY of uterus diagnosed by roentgen examination (abs), 834

ULCER, gastric and duodenal, roentgenographic study of relative incidence of (abs), 275
Hunner's, treatment of, with deep roentgen therapy (abs), 563
syndrome, duodenal, caused by ankylostomiasis, 39
URETER, roentgen sign of acute obstruction of (abs), 278
URETHRA, tumors of (abs), 837
URINARY extravasation (abs), 837
UROGRAPHY. See PYELOGRAPHY
UROLOGICAL complications of cancer of rectum (abs), 284
UROLOGY award, 123
UTERUS, cancer, results of present method of radium therapy as influenced by stage and grade of lesion, 487
cervix, cancer, effect on rate of cure of increased roentgen radiation to parametria, 519
cervix, cancer, elimination of irradiation injuries in treatment of, 494
cervix, cancer, irradiation in (abs), 559
cervix, cancer, irradiation of, combining radium and supervoltage roentgen rays (abs), 560
cervix, cancer, isodose charts for fields of special usefulness in treatment of, 819
cervix, cancer, post-irradiation stricture of rectum and sigmoid following treatment for, 307
cervix, carcinoma, radium distribution factor in therapy of (abs), 560
cervix, carcinoma, roentgen irradiation of pelvis in carcinoma of (abs), 558
instrument for inserting multiple capsules of radium within, in treatment of corpus cancer, 504
roentgen diagnosis of intrauterine hydrocephalus (abs), 834

SCREEN, fluorescing, effect on luminous output of variation of crystal size of (abs), 571
fluorescing, quantitative estimation of actinic value of afterglow of (abs), 571
fluorescing, simple method of detecting experimentally presence of phenomenon of latent image reinforcement in (abs), 571
SCURVY, infantile, critical analysis of roentgen signs of, 575
SEDIMENTATION REACTION, significance of, in regard to prognosis of irradiation of cancer patients (abs), 567
SHOCKPROOF cables and condensers, effect of, on two-valve half-wave rectification (abs), 571
SHOULDER joint, further studies of, with special reference to bicipital groove (abs), 288
joint, treatment of peritendinitis calcarea in (abs), 558
roentgen irradiation of calcareous deposits about (abs), 558
SIGMOID, post-irradiation stricture of, following treatment for cervical cancer, 307
volvulus of (abs), 277
SILICOSIS (abs), 708
acute, occurring in employees of abrasive soap powder industries (abs), 708
SILICOTIC lesions, factors involved in production and development of (abs), 708
SINUSES, dermal (abs), 137
SINUSITIS, nasal (abs), 707
SKELETAL system, pseudofractures in diseases affecting (abs), 287
SKIN, artificial decrease of radiosensitivity of, in roentgen therapy, 811
diseases of, irradiation in (abs), 566
myxomatous cysts of, roentgen treatment (abs), 566
of rabbit, effect of roentgen irradiation on capillary permeability and inflammation in, 250
SKULL, roentgen changes in vault of, accompanying diseases resulting from metabolic disturbances (abs), 269
SOAP POWDER, abrasive, industries, acute silicosis occurring in employees of (abs), 708
SPINAL canal, use of thorotrast in roentgenologic study of, 214
cord, intramedullary epidermoid cyst of (abs), 839
cord, tumors of, roentgen therapy of (abs), 431
cord veins, roentgen diagnosis of dilatations of, 476
SPINE, lipiodol misplaced in (abs), 838
thoracic, pyogenic osteomyelitis of, presenting as primary pulmonary disease, 219
SPLEEN, metastasis to, from primary carcinoma of breast (abs), 136
SPONDYLITIS, syphilitic, 756
STENOSIS, aortic diagnosis of, 366
bronchial, and unexpandable lungs (abs), 709
pulmonary, diagnosis of, 366
STEREOPTICS, roentgen-ray, investigation into some practical aspects of, 682
STEREOROENTGENOGRAMS, device for measuring depth in single-film, 682
single-film, new and simple method of stereoroentgenography, 682
STEREOROENTGENOGRAPHY, fallacy in current practice of, 682
STEREOROENTGENOMETER, John, analysis of roentgen pelvimetry by, in 379 cases, 742
STEWART, HARRY MYRREL, 1876–1942, obituary, 413
portrait, 413
STOMACH, bleeding associated with extramucosal tumors of, 442
cancer, factors influencing curability of (abs), 131
carcinoma, classification of (abs), 130
diaphragmatic hernia of (abs), 276
leiomyosarcoma of, 393
roentgen visualization of, without use of contrast media (abs), 275
secondary lymphosarcoma of, 450
STRICTURE, post-irradiation, of rectum and sigmoid following treatment for cervical cancer, 307
rectal, lymphogranuloma inguinale producing (abs), 277
SUBLUXATION of navicular bone, retrolunar dislocation of capitate with fracture of (abs), 288
SURGERY and irradiation, combined, in treatment of carcinoma of pelvic colon (abs), 561
SURGICAL aspects of ruptured intervertebral disc (abs), 426
problem of chronic gastritis (abs), 130
SUTURE METHOD, accurate placement of radon seed by (abs), 141
SYNOVIOMA, roentgenographic recognition of (abs), 286
SYPHILIS, vertebral, roentgenographic diagnosis of (abs), 427
SYPHILITIC spondylitis, 756

TALC dust, compensation claims for disability due to, in New York State, 11
miners and millers in St. Lawrence County, New York, report of study of, 11
mining, tremolite, dust hazard in, 11
workers, roentgenological findings in, 11
TEMPERATURES, effect of high and low body, upon growth of irradiated mouse sarcoma 8 (abs), 568
TERATOMA testis (abs), 837
TESTICLES, irradiation control of metastases from tumors of (abs), 562
treatment of carcinoma of prostate with irradiation of (abs), 562
TESTIS, teratoma of (abs), 837
TESTS, patch and PPD, and roentgen-ray correlation (abs), 712
TETRALOGY of Fallot (abs), 273
of Fallot, diagnosis of, 366

tympany of, diagnosed by roentgen examination (abs), 834
Uveo-parotitis, irido-cyclitis and tuberculosis, roentgen aspects of investigation into relationship of (abs), 270

Veins, of spinal cord, roentgen diagnosis of dilatations of, 476
Vertebra, dorsal, sarcomatous destruction of, associated with aneurysm of intercostal artery (abs), 274
Vertebrae, cervical, degenerative arthritis of (abs), 840
fractures of, following metrazol therapy (abs), 428
hemangioma of (abs), 427
roentgenographic diagnosis of syphilis of (abs), 427
Virginia Radiological Society, 264
Visual acuity in cataractous eyes, roentgen measurement of (abs), 269
Vitamin B_1, use of, in roentgen therapy, to prevent irradiation sickness, 83
Vitamins B_1 and C and small intestinal change in radiation sickness (abs), 138
Volvulus of sigmoid (abs), 277

War conference, 548
Wilms' tumor, treatment of (abs), 561
Wrist, two unusual injuries of (abs), 287

AUTHOR INDEX TO VOLUME 49

Ackerman, Lauren V., 710
Adsit, Alfred W., 427
Aitken, A. P., 286
Altman, W. S., 833
Amor, Arthur J., 125
Ané, J. N., 742
Anthony, Benjamin W., 600
Apfelbach, George L., 708
Arbuckle, Millard F., 139
Arce, José, 132
Arneson, A. N., 564
Arons, Isidore, 565
Ash, J. E., 835
Ashbury, Howard Hicks, 566
Austen, George, Jr., 580

Bachman, Arnold L., 219
Badgley, Carl E., 135
Baird, L. W., 558
Baker, D. R., 398
Baker-Bates, E. T., 715
Ball, Robert P., 272, 731
Balyeat, Ray M., 227
Banks, Sam W., 428
Barnes, W. A., 662
Barr, Joseph S., 104
Barringer, Benjamin S., 837
Batts, Martin, 134
Batts, Martin, Jr., 135
Beck, Claude S., 273
Beilin, I. S., 276
Belanger, George, 431
Bell, Leo, 159
Benda, C. E., 705
Berg, Gunnar, 271
Berger, R. A., 564
Bernstein, Louis, 705
Bieren, Roland E., 131
Binks, W., 432
Binnig, C., 284
Bird, Gustavus C., Jr., 554
Birkelo, Carl C., 715
Bloch, Robert G., 463
Boland, Thomas B., 717
Bolker, Herman, 135
Borley, W. E., 269
Bowen, J. Andrew, 279
Bowing, Harry H., 487, 516, 561
Bradshaw, Howard H., 714
Braestrup, Carl B., 819
Braund, Ralph R., 136
Broadbent, M., 712
Bromer, Ralph S., 575
Brown, Samuel, 276
Brunn, Harold, 130
Bugbee, H. G., 281
Buirge, Raymond E., 132
Bunts, A. T., 426
Buschke, Franz, 450, 559

Cade, Stanford, 125
Cahill, George F., 835
Cameron, Gladys, 569
Camiel, Mortimer R., 135
Camp, John D., 287
Campbell, Darrell A., 135
Campbell, Willis C., 285
Cantril, Simeon T., 450, 559
Carpender, J. W. J., 398
Carter, B. N., 195
Carter, J. Bailey, 708
Carter, Ralph M., 287
Carty, John R., 349
Cassen, Benedict, 570
Caulk, Ralph M., 99
Cave, Edwin French, 288
Chamberlain, W. Edward, 263
Chambers, Robert, 569
Chan, B. C., 142
Che, Y. T., 706
Chont, L. K., 227
Christiansen, Harald, 272
Christie, A. C., 263
Chuinard, Eldon L., 288
Cipollaro, Anthony C., 566
Clancy, F. J., 283
Clapesattle, H. B., 549
Clark, K. C., 567
Clarkson, J. R., 573, 606
Clement, Gage, 708
Cloud, R. W., 531
Cohen, William, 425
Collings, C. W., 283
Colmers, Rudolf A., 717
Cookson, H. N., 712
Corrigan, K. E., 537
Couch, J. H., 134
Cowie, Dean B., 639, 653, 803
Craig, W. Johnston, 275
Craver, Lloyd F., 273
Crilly, James A., 719
Crimm, Paul D., 712
Crossan, John W., 429
Crump, Armistead C., 272
Curl, Howard, 250

Dailey, Morris E., 130
Daland, Ernest M., 139
Davidoff, Leo M., 476
Davidson, S. Whately, 716
Delano, Percy J., 717
Delfs, E., 834
de Lorimier, Alfred A., 639, 653, 660
Denstad, Torfinn, 568
de Rouville, William H., 137
Digby, K. H., 706
Dippel, A. Louis, 834
Dobos, E. I., 713
Donaldson, J. M., Jr., 711
Donhauser, J. Lewi, 137
Doub, Howard P., 103, 426, 561
Douglas, Bruce H., 715
Dowdy, Andrew H., 234, 564, 803
Dowell, D. Arnold, 265, 564
Dresser, Richard, 536, 538
Dubilier, Benjamin, 803

Earl, David, 837
Edling, Nils P. G., 274
Emerson, Ernest B., Jr., 234
Epstein, Bernard E., 264, 476
Erf, L. A., 142
Erickson, Theodore C., 126
Ettinger, Alice, 783

Farber, Jason E., 709
Farley, Maude S., 431
Faulkner, William B., Jr., 715
Feldman, Maurice, 132, 275, 832
Fine, Archie, 276
Finestone, Edward O., 837
Firor, Whitmer B., 126
Flint, H. T., 573
Fook, W. L., 706
Fowler, H. A., 281
Freedman, Eugene, 756
Freedman, Lester J., 566
Fricke, Robert E., 487, 561
Fried, Carl, 569
Friedman, Milton, 516
Friedman, Paul S., 197
Frostberg, Nils, 834
Fuchs, Arthur W., 420
Fulton, Huston F., 603
Furth, O. B., 662

Gall, Edward A., 104
Garland, L. Henry, 123
Geever, Erving F., 777
Gengenbach, F. P., 713
Ghormley, Ralph K., 427
Glasser, Otto, 572
Glücksmann, A., 568
Goin, Lowell S., 429
Gold, Rubin L., 130
Golden, Ross, 729, 731
Goldhamer, Karl, 702
Golter, H. L., 573
Gosse, A. Hope, 274
Gowar, F. J. Sambrook, 713

Graves, R. C., 837
Gray, L. H., 144
Greenburg, Leonard, 11
Greenfield, Henry, 282
Grier, G. W., 366, 707
Griffith, John Q., 567
Grishman, A., 273, 766
Gross, Sidney W., 706
Guiss, L. W., 837

Haldeman, Keene O., 288
Hallberg, O. Erik, 140
Hamby, Wallace B., 838
Hames, Fred, 141
Hamilton, J. F., 285
Hampton, Aubrey O., 433, 442
Hand, J. R., 282
Happey, F., 144, 573
Hare, Hugh F., 269
Harkins, Henry N., 266
Harper, R. A. K., 832
Harrington, Stuart W., 185, 196
Hart, Vernon L., 287
Harvey, Roger A., 145
Hauser, Harry, 563
Hawes, Lloyd E., 799
Healy, William P., 1, 519
Hendricks, J. W., 562
Henny, George C., 554
Henshaw, Paul S., 569
Herger, C. C., 284
Hill, Harold A., 288
Hinkel, Charles L., 321
Hodes, Philip J., 430, 567
Hodges, Clarence V., 836
Hodges, Fred M., 564
Hoecker, Frank E., 143
Hoffman, Eugene F., 429
Holmes, George W., 701, 799
Holmes, L. P., 834
Holmgren, Bengt S., 277
Hoover, Ruben, 603
Hopwood, F. L., 143
Horwitz, Thomas, 199
Howell, R. D., 562
Howes, William E., 285, 705
Huggins, Charles, 836
Hull, Wayne M., 227
Hyams, J. A., 282

Israel, Harold L., 709

Jacinto, Carmelo P., 709
Jacobs, A. W., 816
Jacobs, Lewis G., 572
Jacoby, Paul, 567
Jacox, Harold W., 480, 566
Jellen, Joseph, 429
Jenkinson, E. L., 455
Jennings, Charles G., 829
Jessel, G., 270
Jones, Horace C., 561

Kamperman, George, 141
Kaplan, Ira I., 126, 430
Kasuga, Kazumi, 710
Katzen, P., 283
Kaufmann, William, 836
Kelly, James F., 265, 564
Kenyon, H. R., 282
Kerst, Donald W., 538
Kibby, Sydney V., 286
Kirklin, B. R., 259, 263
Kirwin, Thomas J., 835
Klein, Edward, 682
Klein, Harold, 682
Klein, I., 558
Klein, Milton, 682
Klemes, I. S., 558
Klinghoffer, Stephen, 240
Knutsson, Folke, 425
K'o, Y. K., 142
Koerth, C. J., 711
Kornblum, Karl, 714
Koven, M. T., 264
Krause, George R., 428, 719, 730
Kremer, Wilhelm, 701
Kreutzmann, H. A. R., 563
Krusen, Frank H., 266
Kulick, Max, 264

Lachman, Ernest, 133
Lahoz, Manuel, 709
Lamerton, L. F., 572, 573
Langsam, Charles L., 428
Latteier, K. K., 455
Lawrence, J. H., 142
Lehmann, Pierre, 811
Lemon, Willis S., 708
Lenz, Maurice, 515
Leucutia, T., 431, 543
Levitin, Joseph, 276, 469
Levy, A. H., 276
Lewis, R. I., 277
Lewis, Raymond W., 593
Licht, Erik de Fine, 426
Liljencrantz, Eric, 560
Lindgren, Erik, 567
Lingley, James R., 104
List, Carl F., 137
Long, Esmond R., 709
Lozner, Eugene L., 405
Lutz, J. Fletcher, 138
Lyons, Clinton G., 393

McCarthy, J. E., 276
McCorkle, R. G., 711
McCullough, J. A. L., 287
Macdonald, Dean, 132
McDonald, Eugene J., 405, 718
McGibbon, John E. G., 706, 715
McMullen, J. W., 275
McNeill, Clyde, 550
McNeill, James H., 180
Macy, Icie G., 550
Mandeville, F. B., 431
Marinelli, L. D., 574
Martin, Charles L., 494, 518
Martin, Hayes E., 136
Martin, Mary, 455
Mayneord, W. V., 144, 573
Mazer, Morton L., 30
Melody, George F., 426
Mensor, Merrill C., 426
Menville, Leon J., 742
Merritt, E. A., 99
Mertz, H. O., 562
Meschan, I., 756
Meyer, William H., 572
Moel, Morris, 177
Mullen, Thomas F., 131
Munger, A. D., 562

Nash, Joseph, 551
Nathanson, Louis, 425
Nessa, Curtis B., 271
Neuhauser, Edward B. D., 829
New, Gordon B., 140
Newell, R. R., 269, 560
Newman, Allen T., 682
Nolan, James F., 504
Nosik, William A., 214
Nowell, Stanley, 278

Odessky, I. N., 715
Ogilvie, Robertson F., 832
O'Neill, John R., 715
Oppenheimer, Albert, 49, 635
Outland, Tom, 398

Pardo-Castello, V., 551
Parker, H. M., 559
Parker, Morris L., 136
Paterson, Ralston, 282
Paul, L. W., 271
Pendergrass, E. P., 263, 430
Pendergrass, Robert C., 729
Penfield, Wilder, 126
Perry, S. P., 398
Pfisterer, W. H., 455
Pohle, E. A., 271
Pollack, Herbert C., 600
Popp, Walter C., 565
Poppel, M. H., 276
Portis, Sidney A., 833
Portmann, U. V., 128, 263
Poulsson, K. T., 567
Powers, Robert A., 707
Pratt, Jean P., 561

Priestley, J. T., 561
Prince, C. L., 836
Pyle, Idell, 795

Quick, Douglas, 10

Raap, Gerard, 77
Randall, A., 562
Read, John, 144
Rees-Jones, G. F., 275, 706
Reinhard, M. C., 573
Renander, Axel, 277, 280
Retzlaff, Leonore, 701
Rhinehart, B. A., 140
Rhinehart, D. A., 140
Rhoads, C. P., 289
Ridlon, G. R., 278
Riesenman, F. Regis, 133
Rigdon, R. H., 250
Rigler, Leo G., 271, 833
Rigos, Frank J., 274
Ritterhoff, R. J., 708
Ritvo, Max, 718
Roberts, Ff., 431, 566
Robertson, H. F., 134
Robertson, T. D., 280
Robinson, J. Maurice, 558
Rodenbaugh, F. H., 715
Ronayne, Frank J., 717
Rose, J. Dudfield, 716
Rosenbaum, George, 699
Rowe, Stuart N., 480
Ruggles, Howard E., 701
Russell, D. A., 431

Sachs, Maurice D., 288, 713
Sahler, Otto D., 433, 442
Sandel, Samuel T., 279
Sandler, Bernard, 560
Sanford, Hawley, 426
Saphir, Otto, 136
Sauer, H. R., 284
Schenck, Samuel George, 285
Schindler, Rudolf, 130
Schneider, Martin, 393
Schulte, T. L., 561
Seal, John R., 349
Seaman, J. A., 284
Seeds, Asa E., 30
Sewell, Robert L., 564
Sgalitzer, Max, 427
Shapiro, A. V., 159
Shehadi, William H., 39
Shiflett, E. Lee, 279
Siegal, William, 11
Silverstone, Sidney M., 819
Singer, J. J., 711
Smith, Adelaide Ross, 11
Smith, R. Manges, 750
Smith, William M., 130
Smithers, D. W., 606
Snead, L. O., 564
Snow, William, 265
Solomon, Harry A., 219
Sontag, L. W., 795
Soto-Hall, Ralph, 288
Spangler, Davis, 558
Speert, Harold, 143
Spillman, Ramsay, 545
Spotoft, J., 567
Stanford, Brian, 570, 571
Starks, Dorothy J., 707
Stauffer, Herbert M., 554
Stebbins, T. L., 279
Steinberg, M. F., 273, 766
Steiner, Paul E., 130
Stevens, R. E., Jr., 836
Stewart, Harold J., 349
Stirling, W. Calhoun, 835
Stone, Robert S., 558
Strauss, B., 283
Strong, J. A., 606
Stutsman, A. C., 139
Sugiura, Kanematsu, 568
Sussman, M. L., 273, 766

Taft, Robert B., 659
Taylor, Henry K., 177
Taylor, Hermon, 716
Taylor, Lauriston S., 570, 660
Thomas, A. Robinson, 712
Thomas, Gilbert J., 279
Thompson, Roy H., 603
Ting, T. P., 574
Torpin, Richard, 834
Tragerman, L. J., 711
Trump, J. G., 531
Tu, C. L., 142
Tuttle, L. W., 142
Twombly, Gray H., 519

Urban, Jerome, 299, 306

Vest, S. A., 836
Vieta, John O., 273

Wallace, William S., 138
Wangensteen, Owen H., 700
Wasson, W. Walter, 718
Waters, Charles A., 126
Watkins, Charles H., 565
Watson, William L., 299
Weatherwax, J. L., 123
Welebir, F., 283
West, Theodore S., 659
Westermark, Nils, 271, 570
Westing, Siegfried W., 587
White, J. Duncan, 717
White, Thomas N., 639, 653
Whitmore, William H., 83
Wigby, Palmer E., 307
Williams, E. Rohan, 270, 278, 280
Williams, Marvin M. D., 571
Wilson, C. W., 432, 573
Wirth, John E., 305
Witwer, E. R., 431
Wolf, Bernard S., 819
Wright, Arthur W., 836
Wyatt, George M., 279

Yater, Wallace M., 133
Yenikomshian, H. A., 39

Zachrisson, C. G., 271